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Materials & Methods

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How Atomic Radiation Affects Engineering Materials

Nylon—Properties and Applications

Practical Applications of Hot Pressing

Surface Finishes for Technical Ceramics

Inert-Gas-Shielded Arc Welding of Lead

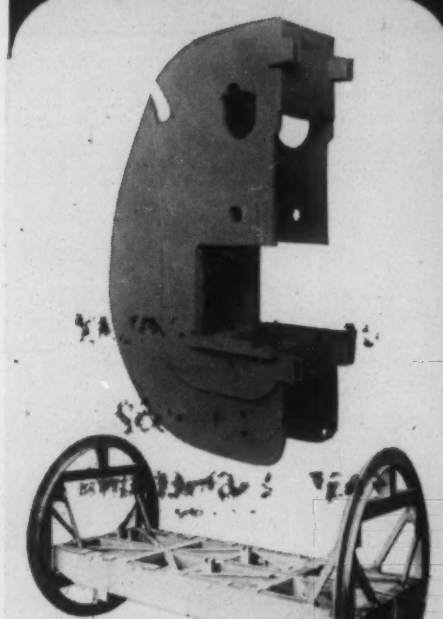
Hot Machining Methods

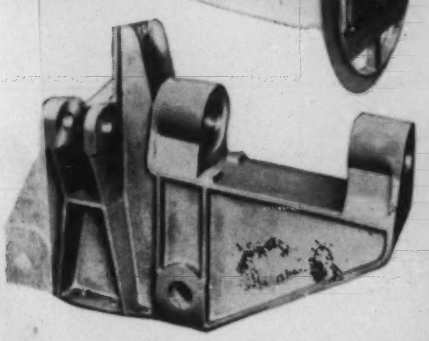
Rare Earth Metals in Magnesium Castings

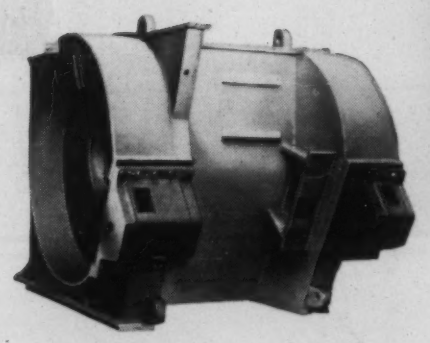
Steel Castings Specifications

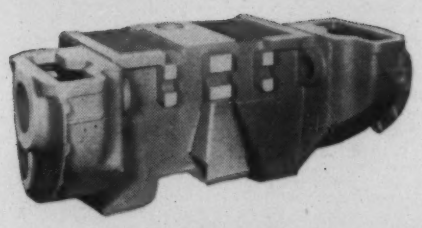
COLD FORMING STAINLESS STEEL PARTS
—Materials & Methods Manual No. 84

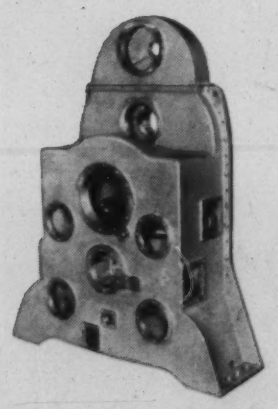
THE MAGAZINE OF
MATERIALS ENGINEERING
DEVOTED TO THE MATERIALS PROBLEMS OF PRODUCT DESIGN AND MANUFACTURE

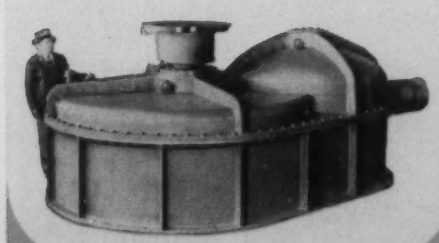












Steel-Weld

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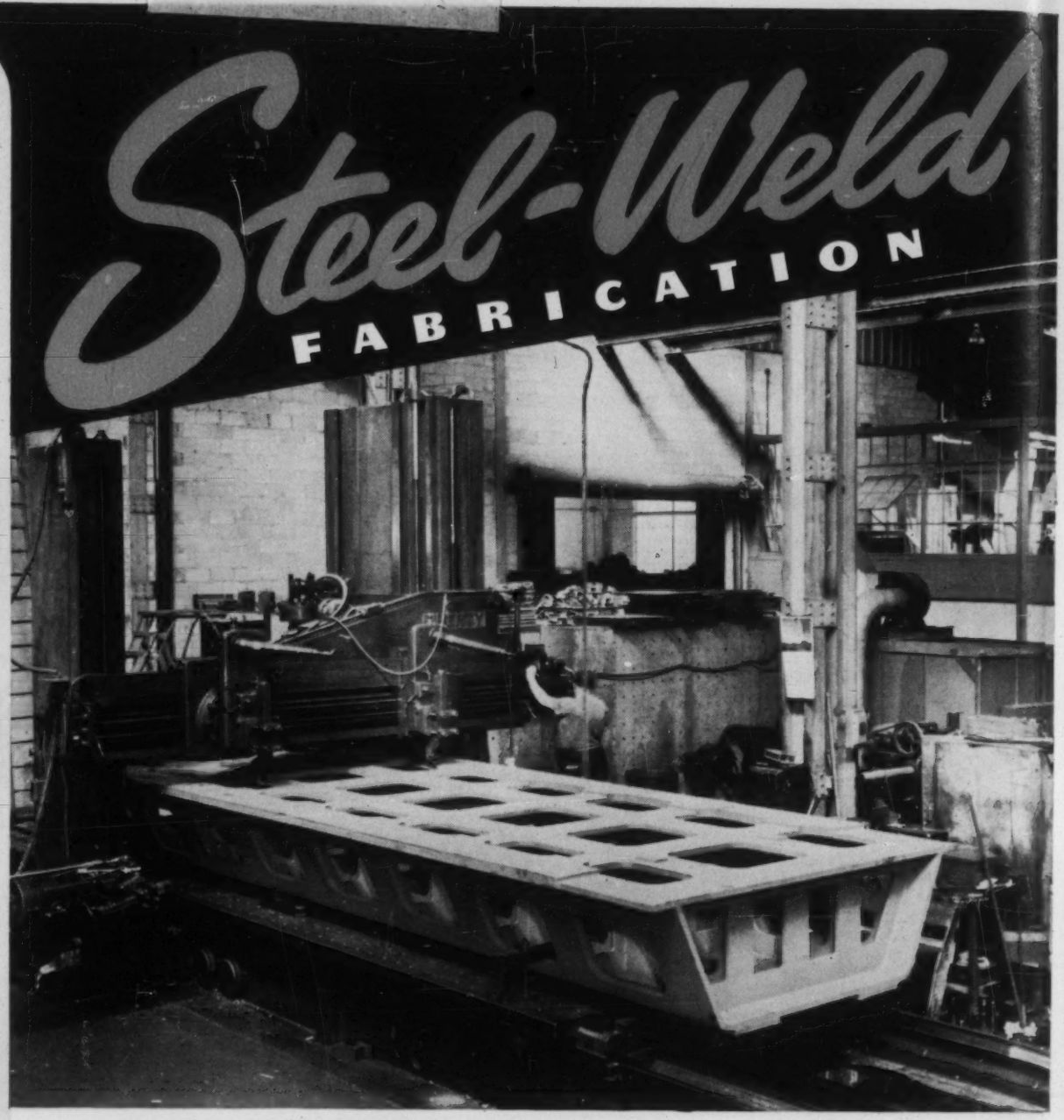

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Feature Articles

• How Atomic Radiation Affects Engineering Materials . . . . . *D. O. Leeser* **75**
What happens to materials under bombardment of nuclear particles

• Nylon—Its Properties and Applications . . . . . *Robert Lurie* **79**
Unusual properties make it a natural for a host of mechanical parts

• Practical Applications of Hot Pressing . . . . . *Jerome F. Kuzmick* **84**
Tungsten carbide dies and shaped pieces, heavy metal parts, metal-ceramics now being produced

• Surface Finishes Improve Performance of Technical Ceramics . . . . *Hans Thurnauer* **88**
Glazes, metallic coatings, silicone treatments, and ground and polished finishes used successfully

• Materials at Work **92**
Aluminum fuel tanks • Phenolic parts • Stainless steel coupling • Alkyd wrench

• Lead Welded by Inert-Gas-Shielded Arc Process **97**
Soft soldering replaced, resulting in reduced production time and improved quality

• Hot Machining Methods for Difficult-to-Machine Metals . . . . . *A. A. Caminada* **98**
A number of different techniques are objectively reviewed

• Rare Earth Metals in Magnesium Casting Alloys . . . . . *J. C. McDonald* **162**
Their addition greatly improves the elevated temperature properties

Materials & Methods Manual No. 84

Cold Forming Stainless Steel Parts . . . . . *Kenneth Rose* **101**

Engineering File Facts

Summary of Standard Specifications for Steel Castings (No. 231) **121**

Departments

The Materials Outlook **3**
Materials Control Orders . . . **6**
News Digest **9**
New Materials & Equipment . . **125**
Meetings and Expositions . . **206**
Book Reviews **208**
Manufacturers Literature . . . **217**
Advertisers and Their Agencies . **232**
The Editor's Page **234**

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The Materials Outlook

New Babcock & Wilcox equipment will make available as tubing a number of unpierceable metals. The French hot extrusion process will be used. . . . A white hot billet, 28 in. long and 8 in. in dia, can be extruded through a die and mandrel into a 60-ft. long, 2-in. dia tube in less than 5 sec. . . . Speed is not the principal advantage, though. Metals like molybdenum and some of its alloys, titanium and certain of the stainless steels, which are impossible to pierce economically, can be shaped on the new equipment.

Nylon is used in foundries to prevent the erosion of aluminium sand core molds caused by blowing sand into the molds. . . . When the two halfs of a core box are put together, core sand is forced into the box under air pressure through two holes in the top. The sand erodes unprotected metal around the holes and at points where the sand hits the mold inside. Nylon bushings at the core box blow holes and nylon strike pads at the spots of greatest wear in the mold cavities proved the solution.

A plastic patch for pipes developed at the Naval Damage Control Training Center, Philadelphia, can be applied in 7 min, will withstand working pressure 20 min later. Patching material consists of fibrous glass cloth, resin and activator, and fibrous glass tape. No surface preparation other than wiping dry is required; the patch will work over jagged ruptures or sunflower bursts, will even join two ends of completely severed pipe. The patch is not affected by gases or liquids in shipboard lines, with exception of high temperature material. No outside heat is required in applying the patch.

Low alloy titanium-boron steels are being investigated for short-time, high temperature applications. Service life of several hundred hours — adequate for many jet engine parts — can be reached. . . . High temperature strength is equal to that of some high alloy steels, but the oxidation resistance is not outstanding. Weld strengths at high temperatures are quite high. . . . The best lean alloys found to date have 2 to 3 chromium, 1 molybdenum, about 0.010% boron and 2 to 4 times as much titanium as boron.

A new magnetic material has a coercive force of 3000 oersteds, higher than any known permanent magnetic material. The new material was developed by the Navy. It beats everything except the platinum-cobalt alloy in available flux density in short magnets with a length to diameter ratio of one or less. Magnets are made by powder metallurgy, in complicated shapes, with close tolerances. . . . The composition is bismuth and manganese, with no nickel or cobalt. . . . The maximum energy product is comparable to that of Alnico (3×10^6 gauss-oersteds) and the Curie temperature is 662 F. No tech-

(Continued on page 4)

The Materials Outlook *(continued)*

nical evaluation with respect to temperature, stability, aging, shock, etc. is available at present.

Reports on recent symposiums on aluminum and magnesium held under Army Engineer auspices at Fort Belvoir are available from the Office of Technical Services, Department of Commerce, Washington 25, D. C. The problems and possibilities of aluminum in product design and manufacture are covered in one report ($3.00). The other book ($2.00) gives basic information on the industrial application of magnesium alloys.

University of Michigan tests reveal that chromium plate deposited from some baths decreases the fatigue strength of steel less than plates from other solutions. . . . A high-speed solution formulation of the United Chromium, Inc. has the least effect on fatigue strength. A 0.001-in. plate from an ordinary solution makes a 35% increase in the stress area of a section necessary to retain the same fatigue strength. An area increase of only 8% is required with the special solution plate.

A 15,000-ton hydraulic forge press made in 1940 in Germany is now in operation at the Aluminum Co. of America, Cleveland Works. It was designed to forge aluminum-magnesium propeller blades, crankcases and spar sections. Iron and steel castings, some weighing more than 120 tons each, were used in the press. The 16 nuts that hold the machine together weigh 10 tons each.

The Army Engineers are trying to develop plastic-coated fabrics and plastic films for camouflage purposes. Burlap stripping and present plastic films are not dull enough to reduce glare satisfactorily. The best bets seem to be polyvinyl chloride films and synthetic fiber, non-woven fabrics bonded with resins into mat-like structures. . . . The Engineers are also looking for a dust proof, waterproof membrane to go under airfield landing mats. Prefabricated bituminous material — burlap impregnated with asphalt — is not strong enough and is affected by gasoline. Rubber sheeting has also been turned down. . . . Another objective is plastic cartographic and grid bases for maps. These may not be vulnerable to temperature or humidity. Glass cloth impregnated with resin and vinyl films are being investigated.

The Ferro Corp. has opened a new glass fiber plant in Nashville. The products will be roving, chopped strand and chopped strand mat products for reinforcement purposes. . . . Ferro will concentrate on product development and production techniques for other manufacturers who want to investigate glass-reinforced plastics. Ferro will design the product, tool for it, find the right composition and go into trial production on regular equipment.

A report, "Isotopes - A Five-Year Summary of U. S. Distribution," is available to the public from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for $1.00 per copy. A summary of isotope applications considered to be of significance to industry has been compiled from the Five-Year Summary and printed separately as Document TID-5078, available at the Office of Technical Services, Depart-

(Continued on page 6)

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The Materials Outlook *(continued)*

ment of Commerce, Washington 25, D. C., for 30¢ per copy. The full report on isotope distribution for five years shows more than 10,000 radioactive isotopes and 2000 stable isotopes have been distributed to users in the United States and 750 radioactive isotopes to users outside the United States.

Materials Control Orders

A summary highlighting actions of the NPA affecting engineering materials during the period from May 11, 1952 through June 10, 1952.

ALUMINUM

Because of improved supply, relaxation of controls on aluminum during the third quarter and removal of controls during the fourth quarter are expected.

ANTIMONY (Order M-39)

Improvement of the supply situation has made it possible to revoke this order.

BISMUTH (Order M-48)

Because supplies are considered sufficient to permit such action, this order is revoked.

CADMIUM (Order M-19)

Because of the improved supply situation, this order is revoked.

COPPER (Orders M-82, M-86)

As amended, order M-82 permits distributors to obtain replacements for brass mill products which were delivered from inventory to fill ACM orders for military, AEC and machine tool programs. An amendment to order M-86 permits replacement of copper wire mill products which were delivered from inventory to fill similar orders.

An amendment to direction 1, order M-16 would allow 75% instead of the present 50% per month in advanced allocations of domestic refined copper for two months and the purchase of 100% of foreign copper two months in advance. Changes in the method of allocating copper to provide an equitable distribution are under consideration. NPA would allocate the entire domestic production estimated at about 80,000 short tons and authorize refined copper users to buy up to 50,000 short tons of foreign copper per month.

IRON AND STEEL (Order M-25)

An amendment relaxes metal can order M-25 to allow increased use of cans for some segments of industry. Among other revisions, it permits unrestricted use of cans made entirely of black plate and of cans made of tin plate waste-waste or tern plate waste-waste.

Because of the continuing scarcity of nickel, NPA is considering placing more stringent restrictions on the use of nickel-bearing stainless steels. An increased supply of nickel is not expected in the foreseeable future. Removal of controls from merchant pig iron is under consideration because of a greatly increased supply in recent months accompanied by a decrease in demand. Effective Aug. 1, 1952, producers of cold finished carbon and alloy steel bars will be required to reserve specified tonnages of 1½ in. and larger bars for military production.

LEAD (Orders M-38, M-76)

Because of the improved supply situation, these orders controlling the distribution and use of lead are revoked.

MOLYBDENUM (Order M-81)

Increased facilities and an improved material situation indicate that removal of controls from hydrogen-reduced molybdenum wire, rods, sheet, powder, and other products can be expected.

RUBBER (Order M-45)

An amendment defines Thiokol and makes it subject to this order. The allocation period is the calendar month and there is no small order exemption. The provisions of NPA Reg. 1 apply to Thiokol.

TIN

Removal of controls from all secondary tin mill products, including mill accumulation plate, unmended menders, and unassorted temper tin plate, is expected to occur with the beginning of the third quarter of 1952.

TUNGSTEN (Order M-81)

Because of increased facilities and an improved material situation, removal of controls from hydrogen-reduced tungsten wire, rods, sheet, metal powder, and other products will occur shortly.

ZINC (Order M-9)

An amendment to this order removes all allocation and use controls on zinc but retains inventory controls. However, relaxation of the order permits users of slab zinc to carry a 60-day inventory.

NPA REGULATIONS

Reg. 1—An amendment removes all inventory controls from antimony, bismuth, lead and cadmium, and liberalizes the inventory limitations on zinc.

Del. 5—An amendment transfers the authority to allocate blister copper from DMP to NPA in order to include blister copper under the definition of copper raw materials set forth in order M-16.

Des. 1—An amendment to the designation of scarce materials removes more than a score of items listed previously from those materials subject to the anti-hoarding controls of DPA. Included are natural rubber, latex, antimony, bismuth, cadmium, lead and zinc.

News Digest

Government Administrator Lauds Metals Production

The Government-industry program to step up production of metals and minerals vital to the defense and economic progress of the free world has made substantial progress toward meeting presently-known needs, Jess Larson, Administrator of General Services and of the Defense Materials Procurement Agency, said recently.

In his first public statement on overall progress of the DMPA program, established last Fall to assist industry here and abroad in tooling up to meet the Nation's greatly expanded materials requirements, Mr. Larson said:

"Although there still are a number of serious gaps in the supply situation, I believe it is safe to say that by the time Government-assisted production now scheduled or in prospect is in full swing, and is added to our already large unassisted production, we not only will be able to meet all defense needs for most of the principal metals and minerals, but that it will be possible to free substantially greater amounts for civilian requirements as well.

"Since it is the Nation's goal not only to build up its military strength but to keep the civilian economy strong, too, it is imperative that we have enough of all basic materials on hand or in sight to supply the needs on both fronts. Insofar as it is possible to do that, I firmly believe we can do it with the program now under way.

"Moreover, I believe the accomplishments to date prove that the job can be done without the Government itself going into the production business, as it did in World War II. Government has a part in the present expansion program, but it is first and last, so far as I am concerned, industry's own program.

"The Government's main interest is in lending a hand, where appropriate, to the end that industrial expansion that is going to occur in any case occurs sooner."

Chemical Refining Process Produces Pure Metal Powders

New technique makes the working of low grade ore deposits economically feasible.

The Chemical Construction Corp., a subsidiary of the American Cyanamid Co., has announced a new technique for metals production. The ore concentrates or metal scrap are treated by chemical methods instead of the usual smelting and refining techniques. The end products are pure metal powders or metal oxides. The immediate effect will not be lower metal prices. The real significance of the process is that it opens a new concept of metal refinement that may change present criterions of economical ore deposits.

The development work so far has been concentrated on nonferrous metals—primarily nickel, copper, cobalt and manganese oxide. In typical processes the ore concentrates are leached in sulfuric acid or ammonia under high pressure at high temperatures. The resulting solution is then filtered to remove the insoluble compounds. It then goes into another autoclave under high pressures and high temperatures. Here reducing agents are introduced to precipitate the metal powders. The process varies, of course, depending on the raw materials and the final product desired.

Several commercial plants to use the technique are now under construction. A cobalt refinery is being built for the Howe Sound Mining Co. near Salt Lake City, Utah. This one plant will increase the world cobalt production 40%. A refinery to produce cobalt, nickel and copper is under construction at the Fredericktown, Mo., mine of the National Lead Co. Another refinery is being built to produce nickel for Sherritt Gordon Mines, Ltd., in Alberta, Canada. Small amounts of cobalt and copper will also be produced in this plant. Other developments are expected in processes for producing oxygen-free, high-conductivity copper powder from copper scrap, brass scrap and blister copper, as well as for producing sintered manganese oxide from low grade manganese ores.

One finished product of the new chemical refining process is oxygen-free, high-conductivity grade copper powder.

There are undoubtedly advantages and disadvantages to this technique. The metal powders must be further processed for casting or extruded into other forms. The big saving is claimed to be in the production costs. This process can be set up close to the ore source with a fraction of the plant expense necessary for conventional heat and electrolytic techniques. Transportation costs and inventory costs are claimed to be lowered dramatically.

News Digest

Weathering Tests on Sheet-Metals Show Importance of Proper Fasteners

Two-year atmospheric exposure tests of a number of sheet metals used in building construction have recently been completed by the National Bureau of Standards. Sheets of aluminum and zinc alloys and of aluminum-coated and galvanized steel were exposed to the weather under conditions closely approximating those found in actual practice. Each metal tested was fastened to bare wooden boards with nails of various materials, both with and without Neoprene or lead sealing washers between the nail head and the sheet. The study was conducted by T. H. Orem of the NBS corrosion laboratory.

Severe corrosion may occur at the point of nailing if the wrong nailing is used, even with building sheet that is highly serviceable when properly installed. Although some other types of nailing will often give good service, the NBS study indicates that, in general, use of aluminum nails and carbon-black-filled Neoprene sealing washers will give the greatest assurance of long trouble-free service, even under severe conditions.

Results of the two years' exposure clearly demonstrate the importance of avoiding certain fastening practices, particularly with aluminum. Bare steel nails, or other uncoated nails except aluminum, can cause serious corrosion of the surrounding aluminum. Bare copper nails, furthermore, showed themselves to be even more corrosive than steel nails to the surrounding aluminum. The cadmium-plated and the galvanized nails caused no corrosion while their coatings remained intact. The cadmium itself corroded away in some cases, however, exposing the steel nail, and the zinc showed signs of doing so.

The aluminum-coated specimens behaved similarly to the aluminum-alloy specimens. Neither the galvanized nor the zinc-alloy sheets showed more than slight corrosion of any type under any condition of use. The galvanized sheets showed no corrosion from aluminum, galvanized and cadmium-plated nails, and only slight corrosion from bare steel and copper nails. Similarly, the zinc alloy sheets showed no corrosion from galvanized nails and only slight corrosion from bare steel nails.

Sealing washers are commonly used under the nail heads when metal building sheets are nailed, and this is a highly desirable practice for several reasons. In addition to their waterproofing value, proper sealing washers reduce corrosion possibilities by keeping the nail out of contact with the sheet metal. Therefore, with proper sealing washers, it makes little difference what nails are used. Some washers may not continue to give a good seal, however, and in any event electrical corrosion currents may flow over the surface of the washer when moisture is present.

Carbon-black-filled Neoprene washers were found to weather better than ordinary Neoprene washers in the NBS tests; the latter tended to harden. Lead sealing washers caused no appreciable corrosion of specimens exposed at Washington but did cause substantial corrosion of specimens that were exposed in marine atmosphere.

Toothless Saw Made of Steel Box Strapping Cuts Metal

Reduced costs and saving in scarce metals foreseen.

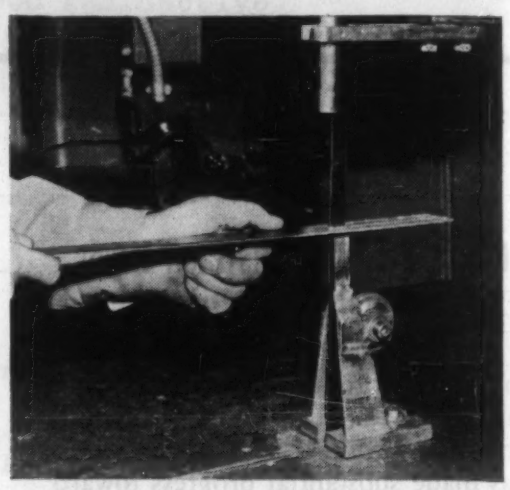
A method of sawing stainless steel and other high alloy sheets using as blades ordinary steel box strapping without teeth has been developed by Solar Aircraft Co. The new toothless sawing method will reduce industrial accidents, save expensive saw blades, and reduce the use of scarce strategic metals in the making of saw blades.

The new development is the work of Jack Prince, a Solar methods analyst. Prince was given an assignment to see if Solar could cut down its present expenditure of several thousand dollars a month for band saw blades. While studying sawing procedures, Prince noticed that saw blades seemed to cut as well with the back of the blade—the part without teeth—as they did in the conventional manner. He decided to try a toothless blade and see if it would work. The only metal that was handy for his experiment was some common steel strapping used to wrap boxes of materials at Solar. He took enough of this metal to equal the length of a band saw blade and tried it out. It seemed to saw even better than a standard blade, it lasted longer, and was much safer.

Solar has only made preliminary studies of the new technique and does not yet know how extensive its results will be. However, the early tests show these facts:

1. Saw blades without teeth, made of cheaper materials than standard saw blades and without the strategic element content of the latter, will last for amazingly long periods compared to ordinary saw blades.

2. The toothless blades can cut stainless steel and high alloy steels, and have satisfactorily cut tool bits, files and cobalt steel. They work best at high speeds and have only been tested thus far on band saws.



Solar Aircraft Co.'s new method of sawing stainless steel uses a toothless blade made of ordinary steel box strapping material. The technique is claimed to have tremendous cost-saving possibilities for industry.

The basis of band sawing at high speeds is that the friction of the saw blade quickly heats the metal being cut to the melting point and literally burns its way through. Ordinary saw blades have been equipped with teeth largely on the theory that the teeth acted as tiny oxygen scoops to bring oxygen to the metal being cut and to speed the burning action. Solar discovered that the toothless blades hardened and roughened within the first few seconds of use to a point where they scoop oxygen as well or better than blades equipped with teeth.

One reason why conventional saw blades have shorter life is that they break easily at the points where the teeth have been cut, where stress is concentrated. The toothless blades eliminate this problem.

News Digest

Powder Metallurgy Cuts Arsenal Production Costs

Savings affected on rotating bands and fuse components.

Savings estimated at $20,000,000 a year through new production methods have been announced by Colonel W. E. Becker, Commanding Officer of the Frankford Arsenal. These savings have been made possible by the application of powder metallurgy to a mere handful of metal components, some of which are already in production and others practically ready for release. It will be some time before the full effect of the powder metallurgy investigation program is known, and while there are many limitations to this method of working metals, wherever an advantage in its use is seen it is being applied.

A 90-mm rotating band of sintered iron currently in production, which costs about one-third less than the equivalent copper or gilding metal rotating band, enables firing a 90-mm shell at armor-piercing velocities not possible with a gilding metal band. The same type material, which is impregnated with a solid lubricant to avoid excessive wear in the gun, is also being studied for application to other sizes and types of artillery ammunition as a means of conserving the huge quantities of copper used heretofore.

Another example is a small but vitally important slider used in one of the mechanical time fuzes designed at the Frankford Arsenal. Made from sintered brass powder, the scrap loss is virtually nil, where previously around 60% of the metal used in the form of bar stock ended up in the scrap heap. All but one machining operation have been eliminated. Again at a saving of one-third the cost, this tiny powder metallurgy item alone is estimated to save the taxpayer nearly one-half million dollars. A pair of tiny centrifugal gears which formerly cost 24¢ each are estimated to cost only 2¢ when made by powder metallurgy. Now nearly ready for production, this component is a large-quantity item, and the saving on it alone is considerably over $5,000,000. Three other fuze components which today are cut laboriously from bar stock or metal strip, and which will be ready for production shortly, will show a combined saving of more than a $1,000,000. Rates of production are faster, and the quality of the end product is at least equal to that of the parts made by the former method.

One item on which there may not be an actual saving in cost will speed up the production of an artillery fuze which has been delayed due to the shortage of certain types of seamless steel tubing. Preliminary tests have shown the sintered iron product entirely satisfactory. If the important large-scale functioning and safety tests confirm its acceptability, early production, made possible by powder metallurgy, will bring greater effective fire power at an earlier date than is otherwise possible

---

Atomic Waste to Lower Cost of Radiography

Industrial radiography of a wide range of metals and metal products at greatly lowered costs through the utilization of atomic waste products is forecast in a survey conducted at the Stanford Research Institute for the Atomic Energy Commission.

Summarizing the results of the survey, Paul J. Lovewell, director of the research group, explains that certain by-products of atomic pile production, now waste, can be recovered and utilized for radiographic inspection at a cost substantially lower than present methods. In addition, it is pointed out that radioactive fission products, used in conjunction with Geiger counters and suitable film, makes it possible to develop many interesting and useful techniques for measuring and controlling a number of industrial processes.

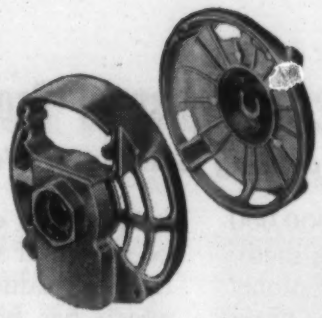
The availability of fission products at low cost would open up the whole field of radiography, both nondestructive and medical, to their use, according to the Stanford survey. The advantages of using fission products, it is pointed out in the survey, lies in their low cost, their availability, and the different energy levels obtainable in comparison with present sources.

Radiation instruments to measure such properties as liquid levels, the

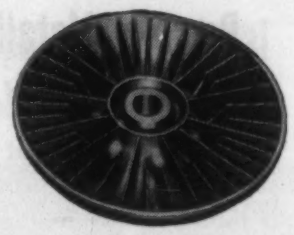
(Continued on page 13)

Matter of Fact
BY EDWARD A JOSEPH
EVER WONDER WHY A METAL BRACE SUDDENLY BREAKS FOR NO APPARENT REASON AFTER YEARS OF SERVICE
ACCORDING TO THREE LEADING SCIENTISTS,
MICROSCOPIC EARTHQUAKES
TAKE PLACE INSIDE OF METALS. THEIR MOLECULES SLIP, THUS CREATING A CRACK SO SMALL YOU CAN'T SEE IT —
UNTIL ONE DAY, ONE MOLECULE TOO MANY GIVES AWAY AND THE METAL BREAKS IN TWO
THE ONLY METAL USED IN THE NEW REFRIGERATOR TRUCKS NOW ON THE MARKET IS THE WHEEL AND AXLE ASSEMBLY AND DOOR FRAMES
THE BODY OF THE TRUCK IS FORMED FROM LAYERS OF PLYWOOD STRENGTHENED WITH "SPECIALLY FORMULATED" PLASTICS
PLYWOOD
50 BILLION BOTTLE CAPS
WERE MADE IN THE UNITED STATES LAST YEAR
THEY ARE TURNED OUT SO FAST THAT ELECTRONIC COUNTERS HAVE TO BE USED. THESE COUNT THE CROWNS ACCURATELY UP TO 10,000 UNITS A MINUTE
POWDER METALLURGY, MAKING SOLID MACHINE PARTS BY HEATING AND COMPRESSING METAL POWDERS, IS A $200 MILLION INDUSTRY IN THE UNITED STATES

creative castings



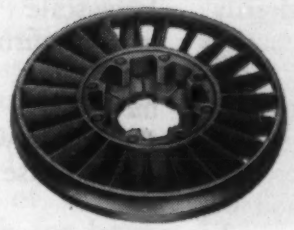
Motor End Frames



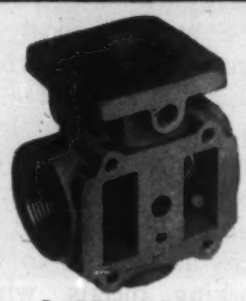
Gyrol Fluid Coupling

Garbage Disposer Housing

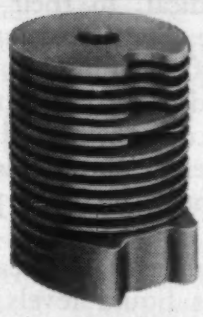
Aircraft Piston



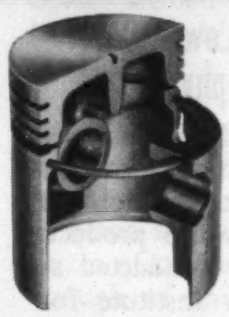
Torque Converter



Fuel Pump Body



Carbon Pile Regulator



Steel-Belted Piston

Alternator Housing

Diesel Permanent Mold Piston

Wing Actuator

Air Connector

Launching Barrel for Bazooka

For many years the foundry of Thompson's Light Metals Division quietly cast thousands and thousands of hard-to-make precision parts in light alloys of aluminum and magnesium.

Word got around that Thompson had the experience and facilities to cast light-weight, strong, heat-resisting alloy parts in permanent molds and high pressure dies—which eliminated the weight problems of ferrous counterparts. One by one manufacturers came to Thompson for help and advice when they learned that the close tolerances achieved by Thompson cut machining and finishing costs.

Today, our capacity is channeled to top-rated jobs. We're building additional facilities as fast as possible and, in the meantime, Thompson services, as always, are at your command. Our entire staff of creative engineers is ready to help you plan new parts or re-design old ones for the future.

A THOMPSON STORY TOO BIG TO HIDE!

Thompson Products, Inc.

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LIGHT METALS DIVISION

News Digest

continued from page 11

thickness of material, or density, though now available, would become more economically feasible through the employment of low cost fission products as a source of radiation. The use of fission products in this connection should greatly expand the application of control instruments to a wide variety of industrial tasks.

Huge quantities of fission products can be made available to industry at relatively low cost, compared to present limited and expensive sources of radioactivity. A gram of radium, giving one curie of radiation, today costs $15,000 to $20,000, while one curie of radiation from fission products will probably cost between a few cents and a few dollars, depending on the terms on which the Atomic Energy Commission will make them available, the cost of processing, and the extent to which they are utilized by industry.

In addition to their application to radiography and the operation of control instruments, fission products, according to the Stanford survey, have a number of other valuable industrial applications. They appear to be useful in food and drug sterilization, for eliminating static electricity in certain manufacturing processes, improving engine performance and making possible the development of a number of new chemical synthetics.

Russians Well Advanced in Metal Treating and Design

Russian engineering must be rated as first class, according to an article in the June issue of the *Journal of the Society of Automotive Engineers*. Russian technology probably is advanced enough to compete with this country for the export market in all types of machinery and vehicles.

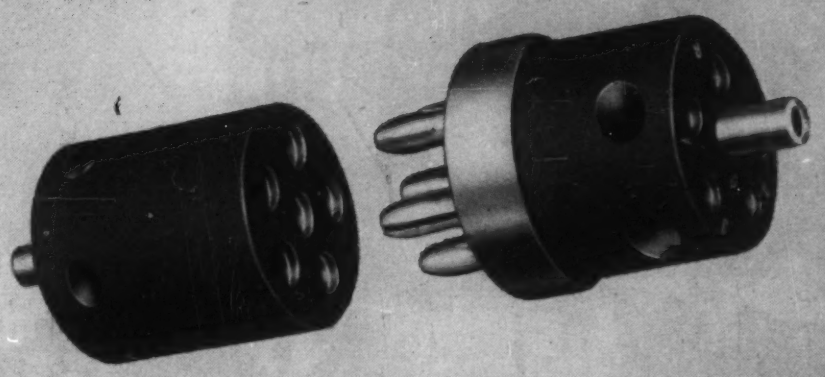
Two Russian-made tractors, captured in Korea, give some inkling of their engineering ingenuity. Although these Stalinetz tractors are copies of a 10-year-old Caterpillar tractor model, they point up some shrewd engineering by the Russians when closely examined.

The Stalinetz tractor is not just a carbon copy of the Caterpillar job.

(Continued on page 168)

where HARD RUBBER is right... use it!

how to SIMPLIFY DESIGNS



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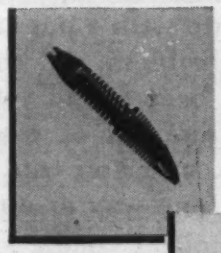

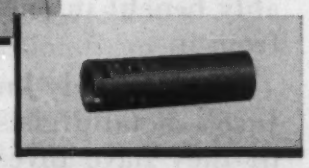

Keep your ACE Hard Rubber and Plastics Handbook handy. Free on request. It's a gold mine of hints like these.

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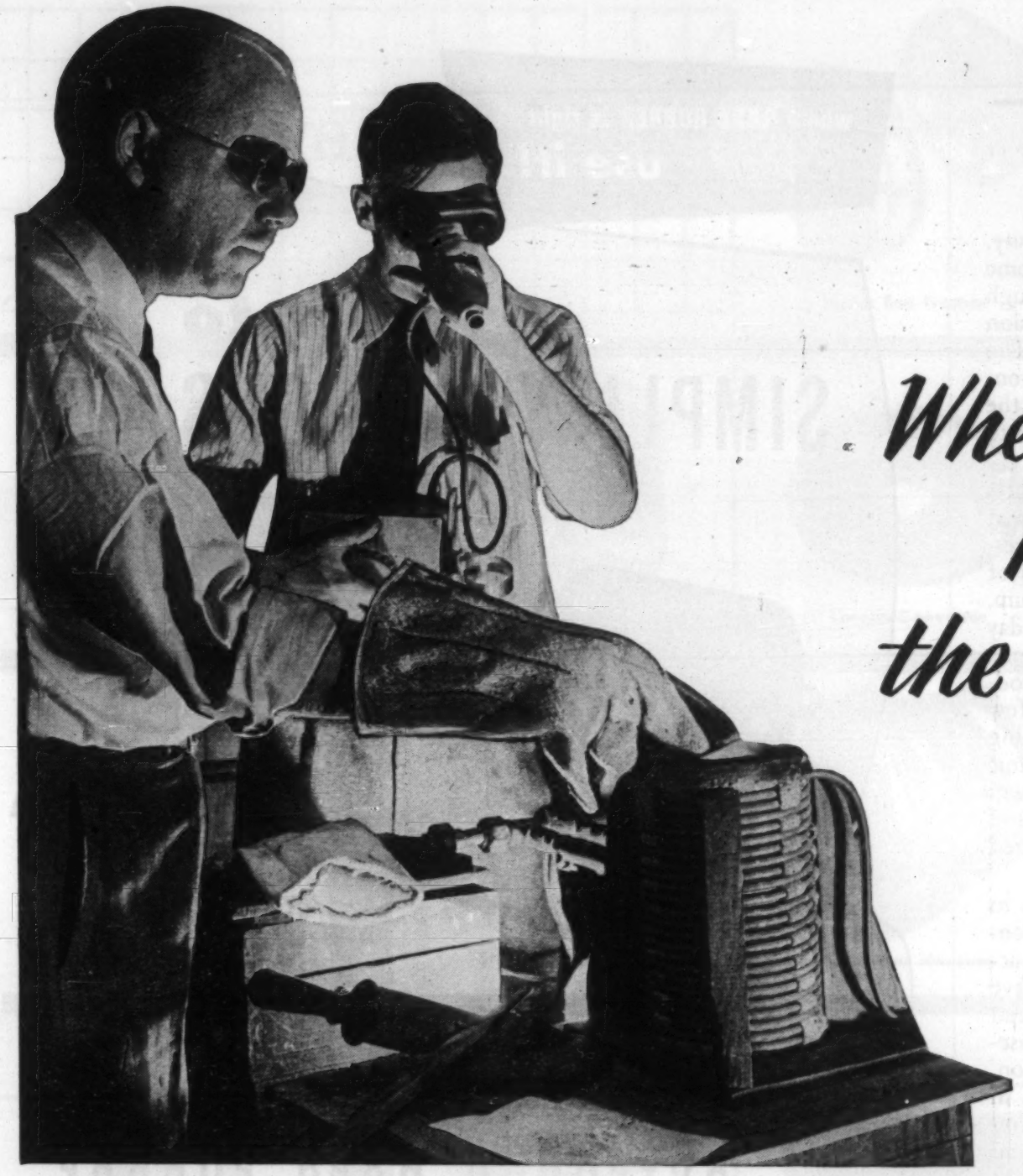

When Nobody Knows the Answer

One of these days you may come face-to-face with a metal problem that does not seem to have an answer.

That is the time to think of these International Nickel Company metallurgists. They are constantly improving and modifying nickel alloys to meet new conditions. They are always ready to help you with specific problems involving metals for aircraft use.

Over the past 50 years, Inco has developed a family of metals for hundreds of different applications. In one branch of the family, for example, is a group of heat-resisting alloys—Inconel®, Inconel "X"®, the Nimonics and Incoloy®— all now important in industry.

Elsewhere on the family tree, you will find other alloys — each with certain special characteristics. Often, there is a better-than-even chance that one of Inco's alloys offers exactly the properties you are looking for.

Of course, this does not mean that somebody at Inco can dip into the files and come up with a pat answer to every new problem. All the answers have not been found yet. But a tremendous amount of research has been done, and you can probably benefit in one way or another from it.

When nobody knows the answer, Inco's metallurgists keep going until they have investigated all possible metals and alloys that might do the job. In fact, the men in Inco's Technical Service (and in their Corrosion Engineering and High Temperature Engineering Services, as well) have one primary goal: to help you determine whether an Inco Nickel Alloy or some *other* metal will serve your purpose best.

No matter what your metal-selection problem may be, all the technical facilities of Inco are available to help you solve it. There is no charge, no obligation of any kind. For prompt technical help whenever you need information about metals, all you have to do is get in touch with: "Technical Service,"

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How Atomic Radiation Affects Engineering Materials

by D. O. LEESER, Associate Metallurgist, Reactor Engineering Div., Argonne National Laboratory

When choosing engineering materials for equipment in atomic energy power plants and reactors, engineers must now consider not only the conventional properties but also what happens when materials are bombarded with nuclear particles.

• THE PERFORMANCE OF engineering materials is now being judged by a new criterion—resistance to radiation damage. Mobile atomic power reactors for military purposes and experimental reactors for research have been announced recently and the evaluation of materials for these applications includes consideration of the effects of bombardment by nuclear particles thrown off during irradiation processes. The conventional properties, such as strength, high temperature resistance and corrosion resistance, are still important, of course. The studies of radiation have, therefore, included the standard engineering materials and the generally known corrosion resistant alloys.

Simplified Theory

The physical, mechanical and chemical properties of materials are affected by the structure of the atoms and their relation to each other. Each atom has a close-packed nucleus compound of protons and neutrons. This nucleus is surrounded by shells of electrons traveling in orbital fashion similar to planetary travel around the sun. Inside the atom there are powerful repelling forces between like charges. There are also even more powerful forces of attraction. Clues to the properties of materials can be gained from a knowledge of these forces within the atoms.

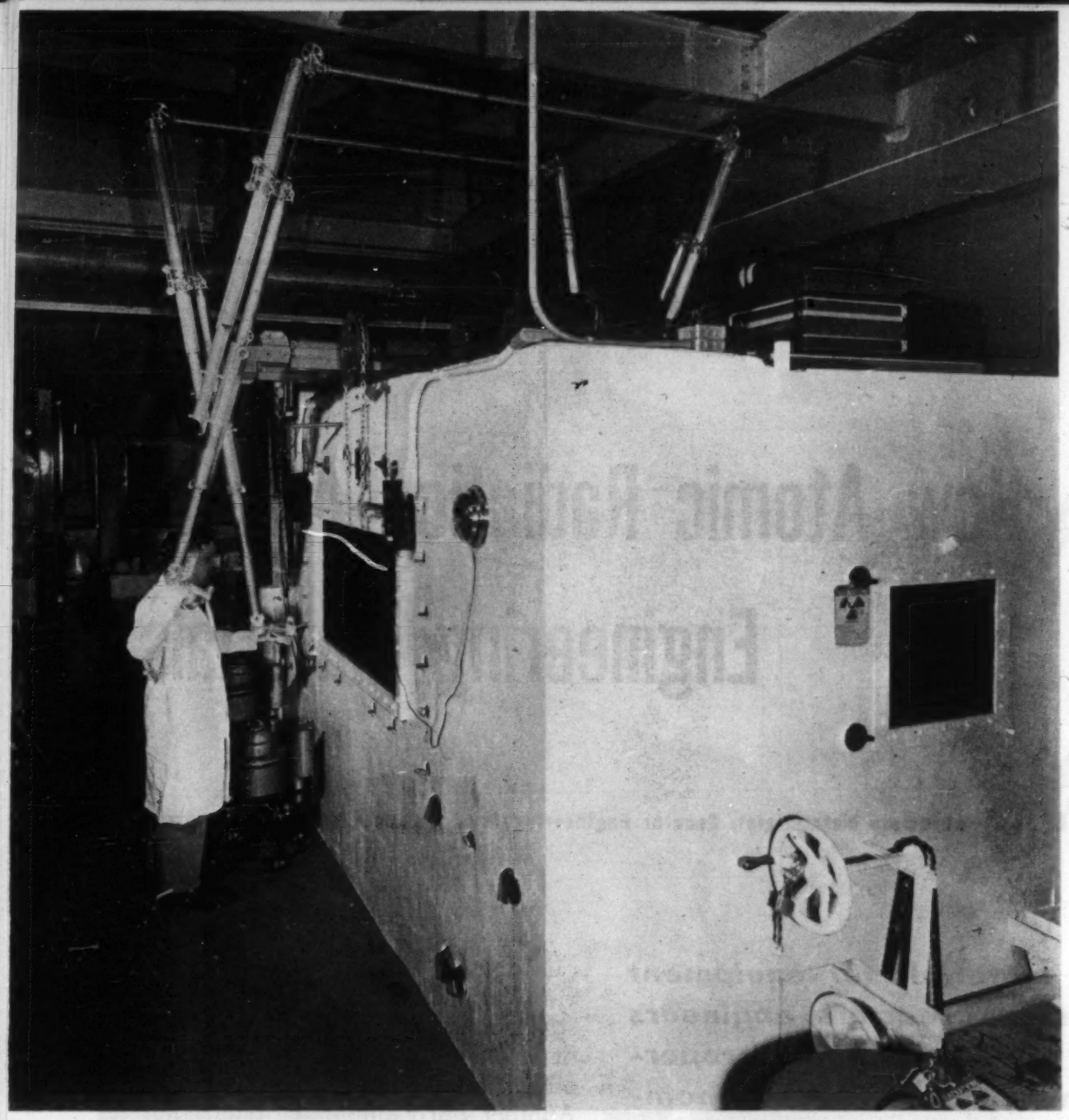
The principal radiations resulting from the fission process in chain reactors are alpha and beta particles, gamma rays, neutrons and fission fragments. The alpha particle is identical to the nucleus of the helium atom. A beta particle is nothing more than an electron traveling at high velocity, while gamma rays are similar to very powerful x-rays. Neutrons are uncharged particles which have been dislodged from the nucleus of atoms. Fission fragments result from the splitting apart of a nucleus of the heaviest atoms (uranium, etc.) into two more-or-less equal parts.

These radiations interact with the atoms of an exposed material by several processes. The most important type of interaction is the collision of a neutron with an atom, causing a dislocation of that atom from its normal lattice position. The struck atom may cause a subsequent or secondary dislocation by knocking other atoms out of the lattice. Another fairly important interaction is the transmutation or conversion of the atomic nucleus itself to form a different element. Finally, a large part of the original energy of the incident radiation goes into the exposed material as heat.

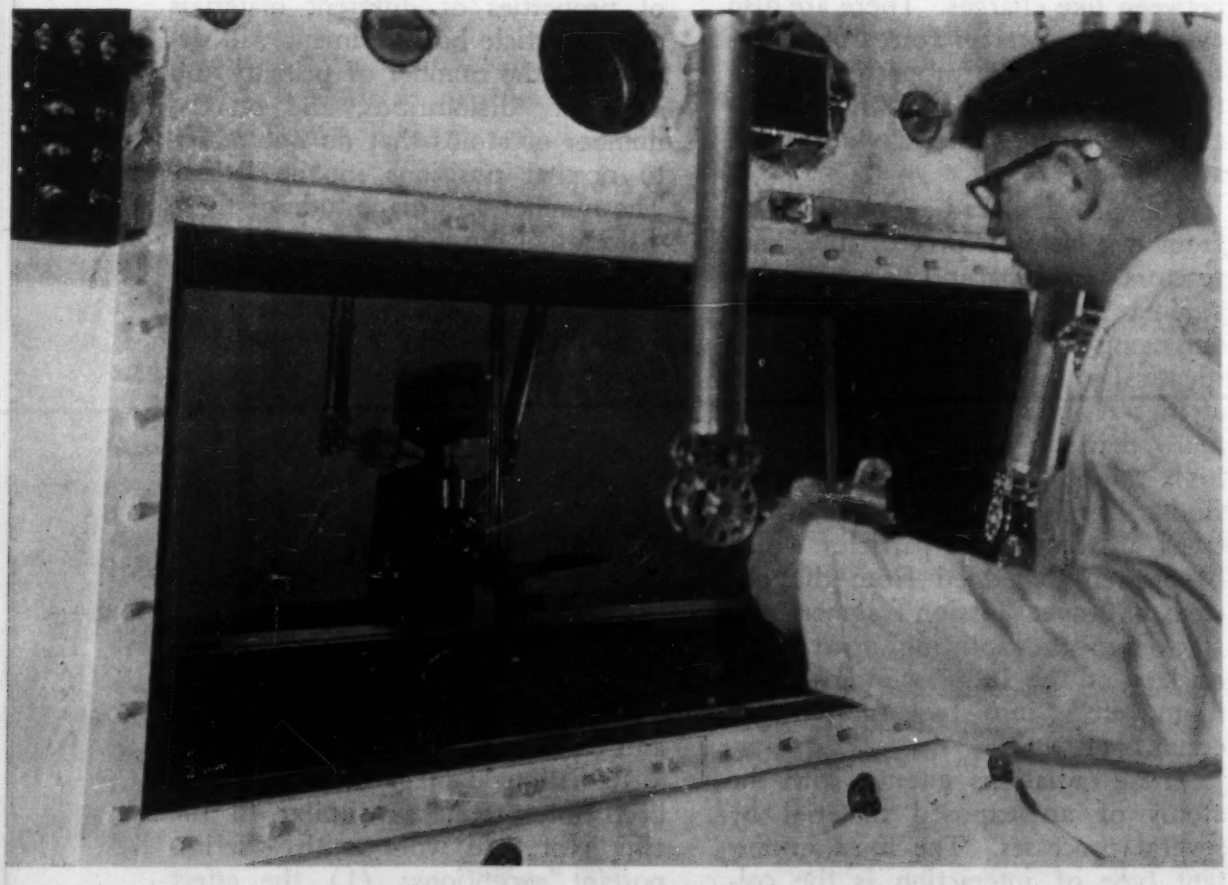
The rate and extent of alternation of properties of different materials under particle bombardment will depend on the number of primary and secondary dislocations, and on the number of atoms that do not return to normal positions in the lattice. The number and magnitude of these dislocations, in turn, are a function of the intensity and time of irradiation exposure until a structure saturated with dislocations or transformations emerges. After saturation, irradiation has negligible effect.

The mechanism of radiation damage is highly complicated. The exact nature of organic-chemical changes due to radiation damage, such as those found in synthetic plastics, has not been analysed completely. Here the damage due to the initial displacement of atoms is masked by damage due to ionization and excitation processes.

Radiation damage in metals has been interpreted as similar to the effects of cold work, with two important exceptions: (1) the effect is applied on a microscopic or ex-



With his hands on master-slave manipulators and a 3-ft-thick window before his eyes, an Argonne engineer makes a precise and complicated measurement on a radioactive specimen. The heavy lead pot in the foreground contains an irradiated specimen and will be opened only after it is rolled inside the concrete cave and the end door is cranked shut. The equipment on the floor beyond the operator draws in room air through filter papers, which are tested periodically for radioactive contamination.



Close-up view showing a hardness tester operated by remote control.

tremely localized scale; and (2) the effect is non-directional. However, recent investigations have challenged the analogy, and the mechanism of radiation hardening is explained as not having a direct correspondence to cold work, but being somewhat more analogous to solid-solution hardening. Whatever the interpretation, the fact remains that in their traverse through materials nuclear particles may cause mechanical and physical changes. These changes are known as radiation damage and may be large when compared with the small amount of energy required to produce the damage. This is analogous to the effects of a lethal dose of gamma rays which raises the body temperature only 0.002 to 0.004 F, while an accidental electrocution may instantaneously burn the body.

Experimental Techniques

The interior of a high-powered reactor during operation is intensely radioactive. Gamma rays and alpha, beta and neutron particles are all present in states of extremely high energy, and every material exposed to this bombardment becomes radioactive to a certain degree, emitting alpha and beta particles and gamma rays in some combinations. Chemical, mechanical and physical tests on radioactive materials are carried out in "hot caves". The "masterslave" manipulators are devices which reproduce the seven human motions employed in grasping, lifting, moving and turning objects. By manipulating handles located outside the cave, the operator can cause duplicate motions to take place beyond the wall. The cave wall is concrete, approximately 3 ft. thick, and has special viewing windows which have good optical-transmission properties. The windows are either liquid-filled glass tanks or laminated plate-glass sections.

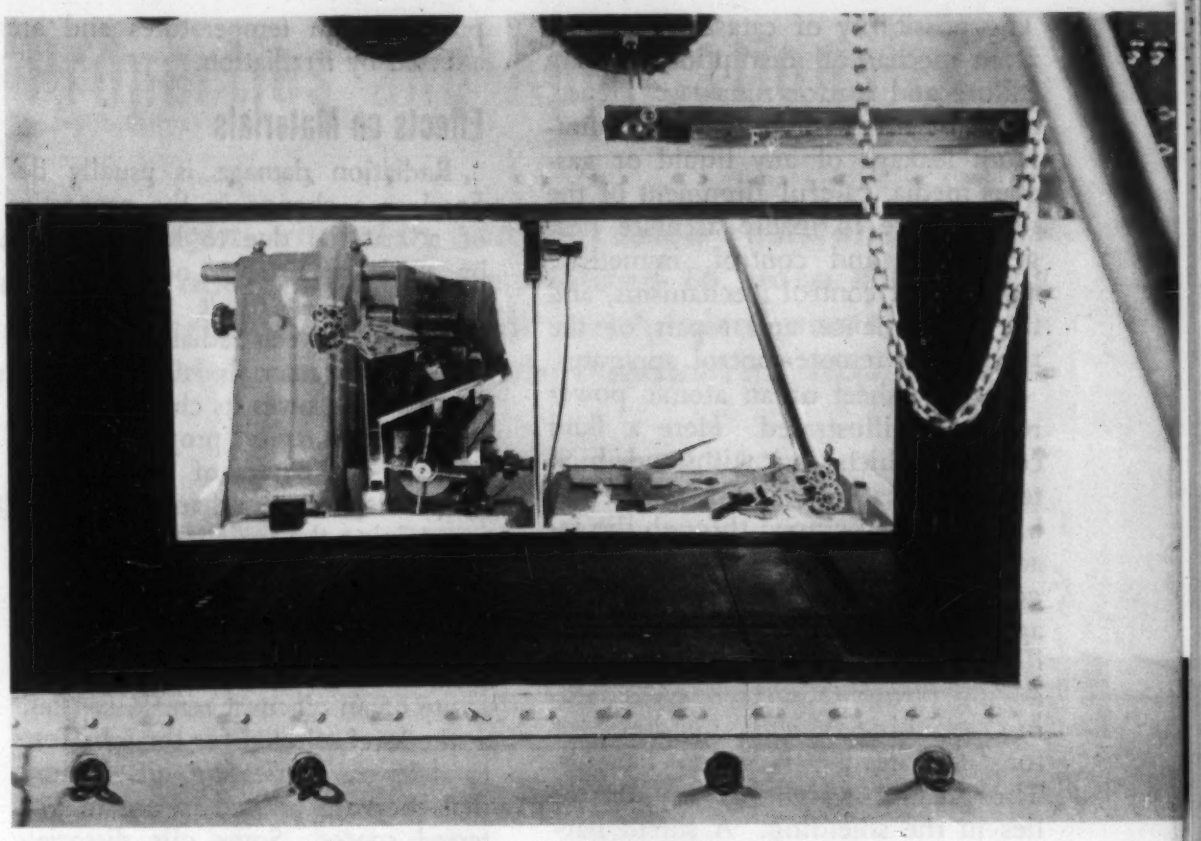
The caves are also equipped to determine the effect of irradiation on the mechanical and physical properties of engineering materials. The equipment includes that necessary for tensile, fatigue, impact, compression, bend, tear and creep tests. Also available is equipment for density, dimensional-stability, electrical-resistivity, magnetic-permeability, corrosion and spalling resistance and notch-sensitivity tests; spring constants, relaxation and stiffness; and chemical analysis.

Argonne engineers have also developed the use of stereoscopic, or

three-dimensional television for experiments where radiation is so intense that the research worker must be at a considerable distance from the materials being handled. The camera uses twin transmitters with tubes at right angles. This permits the separation of the right-eye and the left-eye images. A clear picture in three dimensions is visible to an operator or observer using properly-polarized spectacles.

The ordinary senses cannot detect radiations without the aid of an intermediatory electronic device. In a human body a cell ordinarily recovers from slight damage, but severe injury can cause it to die. If enough cells are destroyed, the body receives detectable injury.

Health physics is the science of protecting personnel against harmful exposure, ingestion and respiration. A maximum permissible exposure to personnel has been set, but actual practice is to keep the dosage as far below this amount as possible. Safeguards are established through the instruction of personnel, use of personnel meters which are attached to the clothing of exposed workers, survey meters and counters, continuous vigilance and monitoring, and periodic physical examinations.



Machine shop operations on irradiated materials via remote control.

A tradition of radiological safety has been maintained in the face of unprecedented problems, and the average exposure of workers has steadily decreased with a take-no-chances attitude.

Reactor Problems

A major hazard associated with the operation of a nuclear reactor is the danger of contamination of the atmosphere or water supply by the accidental release of any radioactivity.

With his special spectacles the operator sees a single picture with a natural perspective, and easily performs the delicate operation of pouring an intensely radioactive fluid from one flask to another via remote control.

The possibility of catastrophe stems from mechanical disruption, cooling failure and reactor runaway. Hence, mechanical problems include minimum leakage of any liquid or gaseous media, careful alignment of the reactor core to insure accurate heat generation and control, immediate response of control mechanisms, and the maintenance and repair of the reactor via remote-control apparatus.

A flow sheet of an atomic power reactor is illustrated. Here a fluid coolant, which can withstand high temperatures and radioactive bombardment, is pumped through the reactor. From the reactor the medium goes to the heat exchanger and back again, after passing through auxiliary systems. This method of producing power requires heavy shielding weighing several hundreds of tons to prevent radiation hazards. The greatest weight of any reactor lies in the shielding. A shield having the highest efficiency per unit volume becomes the lightest shield. To date, the shielding problem has been an important factor in delaying small atomic-power installations for locomotives and airplanes.

Conventional coolants generally have limitations in that one or more properties do not meet desired characteristcis. The characteristics required are: (1) low cross section to neutrons; (2) corrosion resistance to materials used in reactor construction; (3) low partial pressure at elevated temperatures; (4) good heat transfer; and (5) stability under effects of irradiation.

Lubricants are also a problem in reactors. Organic lubricants do not hold their viscosity. They decompose at high temperatures and are affected by irradiation.

Effects on Materials

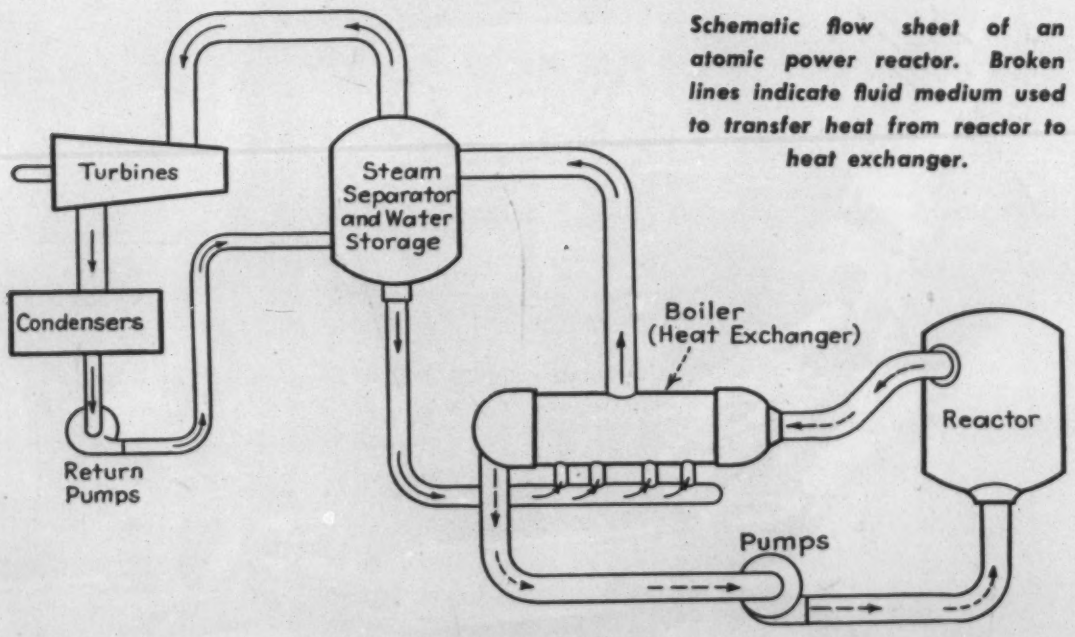
Radiation damage is usually defined as a change in the properties of a material due to bombardment by nuclear particles or radiations. These changes result from atomic collisions between radiations and the atoms of materials under attack. Since a solid owes its chemical, physical and mechanical properties to the position and nature of its atoms, irrespective of the mechanism involved in attaining the various positions, radiation may cause a change in the behavior of the materials.

Oils—In order to serve the purpose of an efficient lubricant, the viscosity of an oil must remain constant at the level selected for the job. Tests to date on lubricating oils indicate that they are limited to use in protected spaces. Some oils dissociate into gases and liquids, while others dissociate into gases and gels. The major physical property changes in oils during radiation include changes in color, viscosity and index of refraction. In all cases the changes in the viscosity and index of refraction are proportional to the duration and intensity of bombardment. Two questions are yet to be explained about the effect of irradiation on oils: (1) what the effects of oxygen and other gases are in radiation damage; and (2) why some organic materials appear more resistant than others.

Elastomers—The known effect of irradiation on natural and synthetic rubbers tested has been confined to weight losses; there has been no apparent effects on elasticity or color. However, these results are from samples irradiated for only short periods. Data on the effect of extended exposures are not available at this time.

Electrical Insulators—Specimens of alumina, zircon, beryllia, siliminite, mica, magnesia and quartz have been irradiated. There is an indication that some color changes occur, along with a decrease in electrical resistivity. There is some indication that the phenomena are confined to the surface. Of particular significance is that post-irradiation anneals have restored much of the original color and electrical resistivity to many of the materials. In most cases the dielectric strength decreases. Dimensional changes are within the accuracy of measurement.

Plastics—Plastics can be used under irradiation for applications where the total irradiation is limited. In high-intensity radiation zones the service lifetime of plastics is sacrificed, while under low-intensity radiation the service is prolonged. Properties show changes due to a degradation of the molecular structure under irradiation until the plastic crumbles. Some plastic materials evolve gaseous-decomposition products, others evolve liquid-decomposition products, and some absorb oxygen or water vapor. Various types blister and swell, some deteriorate and chip, while others merely shrink. As a rule, there are no pronounced changes in volume resistivity, dielectric strength or arc resistance until the mechanical properties deteriorate completely.



Schematic flow sheet of an atomic power reactor. Broken lines indicate fluid medium used to transfer heat from reactor to heat exchanger.

Acknowledgment

The author wishes to acknowledge the suggestions of the staff of the Argonne National Laboratory in contributing to the preparation of this information.

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Nylon—Its Properties and Applications

Qualities of strength, abrasion and corrosion resistance, noise dampening properties, and ability to be molded to close tolerances all suggest consideration of nylon for mechanical parts, such as gears, bearings, cams, housings, and many other industrial applications.

by **ROBERT LURIE**, Application Engineering, Plastics Dept., Chemical Div., General Electric Co.

● MANY ENGINEERS have specified metal gears and bearings or laminated synthetic gears and bearings for years. These men want to know why nylon can be used to replace these and other mechanical parts.

There are many reasons. Nylon can be used to replace metal or laminated synthetic in mechanical parts on a cost basis alone if two requirements are satisfied. One is that reasonably large numbers of the part are required so that the original investment in a mold will be distributed over many pieces. The other is that the part should be fairly complex, requiring considerable fabrication. Gears are a good example.

In some cases, the part will cost more in nylon. However, the use of nylon can often be justified on the basis of superior performance. Nylon parts operate more quietly than metal, and in many cases they will run without lubrication. Nylon parts are light in weight. They are strong. They are resistant to abrasion. Nylon can be molded with sufficient accuracy to satisfy tolerance requirements of most of the industrial parts for which it is suited. Where extreme accuracy is required, as in precision cams in movie projectors, a machining operation on the molded cam blank can bring the working surface to exact dimension. In the case of gears, the ductility of nylon permits the use of wider tolerances on diameter and on tooth form than on metal gears.

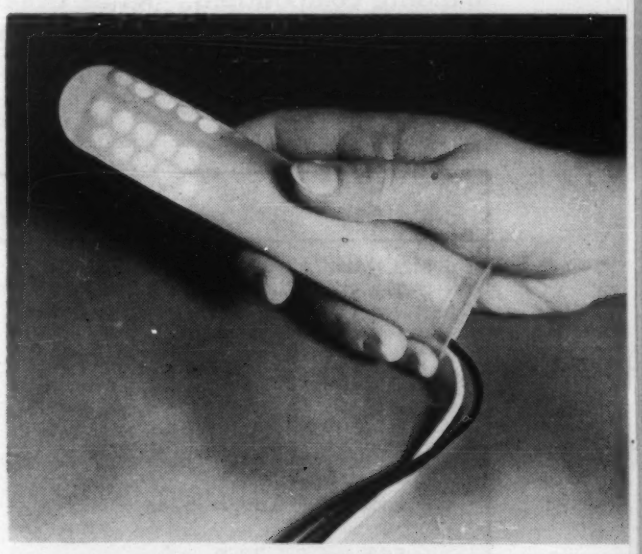
Properties

Toughness at low temperatures, abrasion resistance, strength in thin sections, lightness in weight, self-lubricating qualities, and chemical resistance are the outstanding properties of nylon.

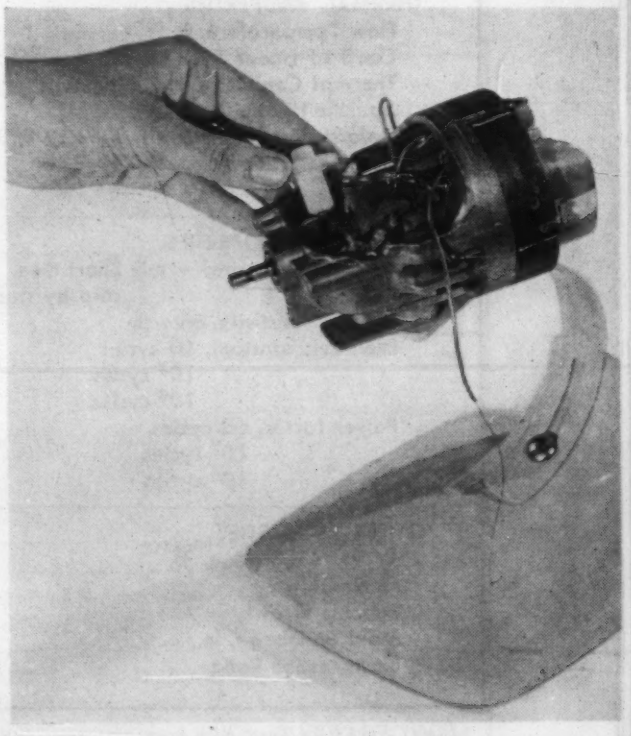
The material also has considerably better heat resistance than any other thermoplastic material, and will withstand continued exposure to the temperatures tolerated by thermosetting materials, The FM-10001 nylon has a heat distortion temperature, under 66 psi loading, of 400 F. Nylon bearings have been known to perform satisfactorily at surface temperatures of about 300 F where lubrication was adequate. Moist heat has less effect upon nylon than dry heat. It has been noted that continuous exposure to dry heat in excess of 250 F will cause embrittlement of the material.

The abrasion resistance properties of nylon are considered extremely good for unfilled plastics. Both gears and sleeve bearings of nylon tested in the presence of sand have outworn metal components under the same conditions of test. In actual practice, nylon gears and bearings seldom fail from abrasive wear. Their failure is usually caused by overheating, which can be prevented by proper design and lubrication. The outstanding abrasion resistance of nylon can be partly attributed to its tendency to completely imbed abrasive particles, sealing over the craters, and thereby restoring the bearing surfaces.

Table 1 shows the physical properties of nylon for the two molding grades FM-10001 and FM-3001. The tensile, sheer and flexural strength of FM-10001 are higher than those of FM-3001. On the other hand, FM-3001 is preferred over FM-10001 in applications where its low-water absorption and high impact strength can be utilized. Articles molded of FM-3001 have greater flexibility than those molded of FM-10001.



A 15-w, 120-v lamp and an aluminum deflector are placed inside this nylon housing, which illuminates interior of automatic washer.



Nylon gear and pinion being inserted in fan housing. Parts are molded in eight units in less than 1 min. Gears are cut free from runner and no further finishing is necessary.

Although FM-10001 does not exhibit the unmolding characteristics of other thermoplastics until the temperature has been raised to 450 F, it does show a loss of rigidity at elevated temperatures. For this reason, it should not be subjected to temperatures above 275 F under load, because of the possibility of plastic creep. The material should not be kept above 300 F for a long time, since it will undergo discoloration and impairment of its toughness.

Nylon has what is considered a high-impact strength, and this property is found at subzero temperatures to a greater extent than in plasticized molding compositions. While nylon has a higher hardness value than other flexible thermoplastics, it is horn-like rather than brittle in nature. This factor, along with its low coefficient of friction, contributes to the abrasion resistance.

The chemical inertness of nylon permits its use in direct contact with a wide variety of chemical solutions. Type FM-10001 is insoluble in common organic solvents, and inert to alkalies. Dilute mineral acids and most organic acids can often be tolerated. Petroleum oils and greases do not affect nylon up to temperatures as high as 325 F. Type FM-10001 has been used successfully in contact with 190 proof grain alcohol without swelling, dissolving or discoloring the alcohol, and retained its dimensional stability.

Table 2 shows the results of chemicals resistance tests of the effect of various common industrial solvents, acids and alkalies on molded FM-10001 and FM-3001. FM-3001 stands up better than FM-10001 in contact with inorganic acids, bases and salts.

In most instances, where nylon moldings are being used, they are offering substantial cost savings. The material cost for a part may be cheaper when it is made of nylon at $1.60 per lb than say bronze, at only $.34 per lb. Although nylon is 5 times as expensive as bronze, on a weight basis, its density is only about one-eighth that of the metal. This gives a substantial price advantage to nylon.

Table 1—Properties of Molded Nylon

Property	Method	FM-10001	FM-3001
MECHANICAL PROPERTIES			
Ten Str, Psi, at: −70 F	D638-44T	15,700	12,900
77 F	D638-44T	10,900	7,000
170 F	D638-44T	7,600	6,760
Elong, %, at: −70 F	D638-44T	1.6	2.0
77 F	D638-44T	50	135
170 F	D638-44T	320	320
Modulus of Elasticity, Psi, 77 F	D638-44T	400,000	260,000
Shear Str, Psi	D732-43T	9,600	8,400
Impact Str, Izod, ft-lb, at: −40 F	D256-43T	0.4	1.6
77 F	D256-43T	1.5	2.7
Stiffness, Psi, 77 F	D747-46T	300,000	150,000
Flexural Str, Psi, 77 F	D790-44T	14,600	9,500
Compressive Stress at 1% Deformation, Psi	D695-44T	4,900	3,000
Creep in Flexure	Arl P-25[1]	90	120
Hardness, Rockwell	D785-47T	R118	R111
THERMAL PROPERTIES			
Flow Temperature, F	D569-44T	480	397
Coeff of Linear Thermal Exp, per °F	D696-44T	5.5×10^{-5}	8.2×10^{-5}
Thermal Conductivity, Btu/Hr/Sq Ft/F/In.	Arl P-32	1.7	1.5
Specific Heat		0.4	0.4
Deformation under Load, %, 122 F, 2000 Psi	D621-44T	1.4	4.2
Heat-Distortion Temp, F: 264 Psi	D648-45T	170 F	130 F
66 Psi	D648-45T	400 F	320 F
ELECTRICAL PROPERTIES			
Dielectric strength,[3] v/mil: Short time	D149-44	385	470
step by step	D149-44	340	410
Volume resistivity, ohm-cm	D257-45	4.5×10^{13}	4×10^{14}
Dielectric constant, 60 cycles	D150-45T	4.1	4.6
10^3 cycles	D150-45T	4.0	4.5
10^6 cycles	D150-45T	3.4	3.5
Power factor, 60 cycles	D150-45T	0.014	0.04
10^3 cycles	D150-45T	0.02	0.04
10^6 cycles	D150-45T	0.04	0.03
OTHER PROPERTIES			
Water-Absorption, %	D570-42	1.5	0.04
Flammability	D635-44	Self-extinguishing	Self-extinguishing
Specific Gravity	D792-44T	1.14	1.09
Mold Shrinkage, In./In.		0.015	0.015
Compression Ratio	D392-38	2.1	2.2

FOOTNOTES: Tests have been performed by ASTM methods unless otherwise indicated. The prefix Arl refers to test methods used in the du Pont Arlington laboratories. Data shown are average values and should not be used for specifications.

(1) Term "creep in flexure" is a measure of the deformation under a prolonged standard load. Results here represent mils deflection in 24 hr of a ⅛- by ½-in. bar, 4-in. span, centerload flatwise to 1000 psi, minus the initial deflection.

(2) Thermal conductivity measured by Cenco-Fitch apparatus.

(3) Samples measured ⅛-in. thick under dielectric strength.

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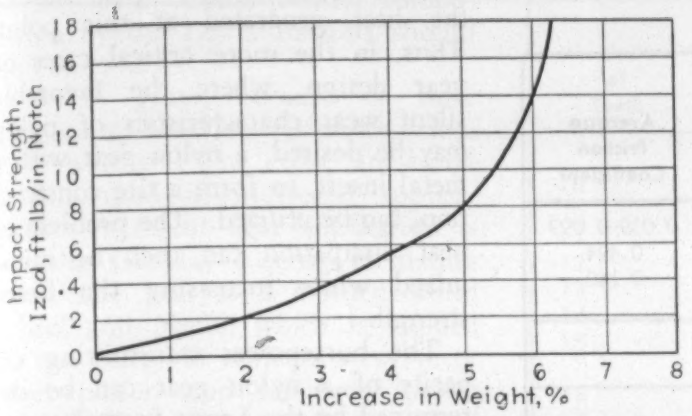
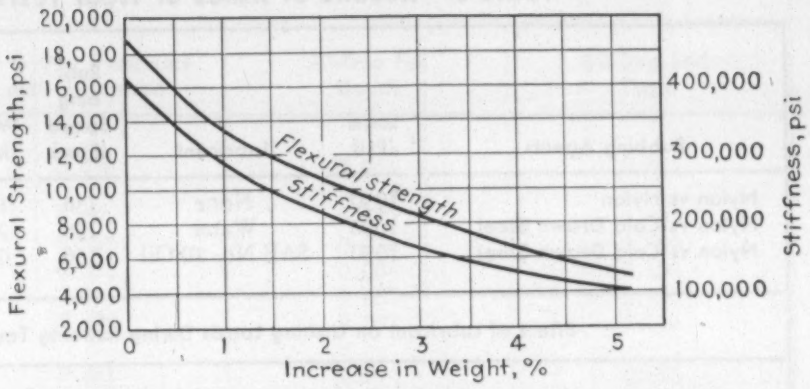
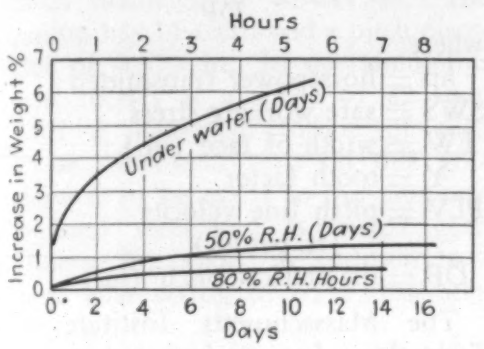


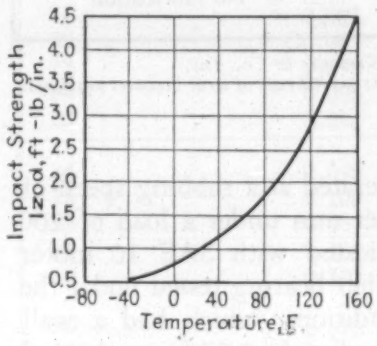
The effect of moisture content on the impact strength of FM-10001 nylon. Continuous exposure to dry heat above 250 F causes embrittlement.



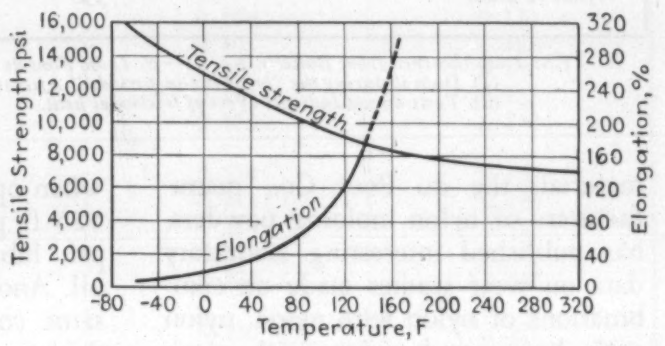
The effect of moisture content on flexural strength and stiffness of FM-10001 nylon.



The moisture absorption of FM-10001 nylon at various relative humidities.



The effect of temperature on the impact strength of FM-10001 nylon.



The effect of temperature on the tensile strength and elongation of FM-10001 nylon. (E. I. du Pont de Nemours & Co., Inc.)

This does not take into consideration the further possibilities for savings in injection molding versus machining operations, and the advantages of molding parts in one piece that were formerly assembled from two or more machined pieces.

Nylon Bearings

The ability of nylon to be molded to extremely close tolerances, as well as in thin sections, has led to its enthusiastic acceptance in the bearing and gear field.

In evaluating nylon as a bearing

Table 2—Chemical Resistance of Molded Nylon

Chemical	FM-10001						FM-3001					
	One Week			One Month			One Week			One Month		
	Gain in Wt, %	Dim. Change, in./in.	Ten Str, Psi	Gain in Wt, %	Dim. Change, in./in.	Ten Str, Psi	Gain in Wt, %	Dim. Change, in./in.	Ten Str, Psi	Gain in Wt, %	Dim. Change, in./in.	Ten Str, Psi
Sulfuric Acid, 3%	2.4	0.0011	8,500	4.9	0.0087	4,600	1.0	0.0028	8,900	1.8	0.0028	8,200
30%	4.2	0.0002	8,800	7.0	0.0065	4,300	1.0	0.0017	9,100	2.0	0.0008	8,300
Sodium Hydroxide, 1%	2.4	0.0014	8,800	4.9	0.0091	9,000	0.9	0.0009	8,800	1.8	0.0039	8,400
10%	1.6	0.0013	9,400	3.1	0.0039	8,100	0.8	0.0010	8,800	1.5	0.0013	9,000
Ethyl Alcohol, 50%	3.3	0.0020	8,500	7.1	0.0150	7,600	3.3	0.0027	8,600	6.2	0.0120	7,700
95%	1.8	0.0006	9,400	3.4	0.0006	8,000	4.1	0.0027	8,100	3.8	0.0158	8,000
Sodium Chloride, 10%	0.4	0.0014	9,200	3.7	0.0022	10,000	0.8	0.0013	9,000	1.6	0.0021	8,100
Ethyl Acetate	< 0.1	0.0003	10,700	< 0.1	0.0004	10,100	0.1	0.0001	8,000	0.3	0.0004	8,400
Carbon Tetrachloride	0.2	0.0008	10,700	0.6	0.0008	9,750	0.2	0.0011	7,900	0.6	0.0008	8,400
Toluene	0.2	0.0008	10,100	0.6	0.0080	10,000	0.3	0.0006	8,200	0.7	0.0008	8,400
Heptane	1.9	0.0013	10,800	0.6	0.0014	10,100	0.2	0.0004	8,600	0.5	0.0014	9,000
Acetone	< 0.1	0.0004	10,400	0.1	0.0020	10,400	0.3	0.0000	8,900	0.7	0.0019	8,200
CONTROL	0.2	0.0013	10,400	1.0	0.0013	9,500	0.4	0.0012	8,700	0.7	0.0011	8,600

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Table 3—Results of Rates of Wear Tests[1]

Rubbing Agents	Load (Psi)	Lubricant	Rubbing Speed (Fpm)	Wear (Mils)	Average Friction Coefficient
Nylon vs Nylon	1050	None	156	1.6	0.039–0.099
Nylon vs Cold Drawn Steel	1050	Water	156	9.0	0.494
Nylon vs Cold Drawn Steel	1050	SAE No. 10 Oil	156	0.9	0.140

Effect of Lubricant on Limiting Loads During Rubbing Tests[2]

Rubbing Agents	Limiting Loads (Psi)	Lubricant
Nylon vs Steel	1550	Oil
Nylon vs Steel	1050	Water
Nylon vs Steel	550	No lubrication

NOTES: Data obtained from Bulletin No. 21—E. I. du Pont de Nemours & Co., Inc.
(1) Data is during the "breaking-in periods." After this period rate of wear becomes negligible.
(2) Tests do not indicate effect of frictional heat.

material, the du Pont Co., manufacturers of nylon molding powders, has published interesting laboratory data on wear studies made on combinations of nylon with nylon, nylon with brass, and nylon with steel, under various loads and speeds, and with various lubricants. (See Table 3). The lowest rates of wear are found when nylon is run against nylon in a dry condition and when nylon is run against steel, lubricated with SAE 10 oil. When nylon is rubbed against brass, the metal flakes off and contaminates the bearing surface.

Rate of wear is greatest at the start, but it tapers off with further operation. This is because after the surface of the nylon is glazed, more intimate contact is established, with a resultant decrease in unit pressure. Rate of wear appears to reach a minimum after about 0.001 to 0.002 in. of surface is removed. In contact with steel or brass, this figure represents the amount of nylon that will be removed in smoothing the metal to prevent further wear. The coefficient of friction decreases during the first few hours of operation and then remains constant; at the same time, the rate of wear becomes practically negligible.

When nylon is rubbing against steel, the limiting load is 550 psi without lubrication. Water lubrication will increase this limiting load by 91%, whereas SAE 10 oil will increase it by 182%.

In determining the influence of wall thickness on the life of a bearing, results were obtained which showed that one bearing, having a wall thickness of 0.125 in., failed by melting after 240 hr of operation when operated at a rubbing speed of 525 ft per min under a load of 200 psi, lubricated with SAE 10 motor oil. Another bearing tested under the same conditions, which had a wall thickness of only 0.020 in., showed no sign of failure after 360 hr of operation. A similar difference was found between thick-walled and thin-walled bearings where nylon acts as an insulator. Tests show that thin-walled bearings at a given speed operate at lower temperatures than with bearings of thicker sections.

Bearings are an important application of molded nylon. In textile mills, the ability to run without lubrication is valuable since oil or grease might soil the material being processed. Finger bearings, parallel blocks for broadlooms, bobbin rims, spindle bearings, thread guides, ring travelers, spin block flyers and roll bearings have been made successfully of nylon. Stove drawer rollers are another application. In all these products, the permanence and ability to run quietly without lubrication are the selling points.

Nylon Gears

In designing gears, where speeds or loads may be excessive, consideration must be taken of the low heat conductivity of nylon, which is 1.7 Btu/hr/sq ft/°F/in. The limiting factor is often the amount of heat generated at the gear teeth. This heat, if not dissipated, will cause deformation through softening of the plastic. Experimental gears have been made with copper shims to facilitate conduction of the heat away from the gear tooth area, in order to prevent undue wear and deformation from the heat generated at this point. Thus, in the more critical cases of gear design, where the favorable silent wear characteristics of nylon may be desired, a nylon gear with a metal insert, to form a tire construction, can be utilized. The problem of heat dissipation can then be minimized while increasing the beam strength.

The horsepower transmitting capacity of a nylon gear can be determined by the Lewis formula:

$$hp = \frac{9.5 \times 10^{-5} \times SWS \times FW \times Y \times PLV}{DP}$$

where:

hp = horsepower transmitted
SWS = safe working stress
FW = width of face (in.)
Y = tooth factor
PLV = pitch line velocity (ft. per in.)
DP = diametrical pitch (in.)

The Massachusetts Institute of Technology has worked out a velocity factor for nonmetallic gear materials such as nylon. Table 4 gives the safe working stress of FM-10001 nylon at various pitch line velocities. The values for Y, the factor for the number and the form of teeth in the Lewis formula are given in Table 5.

Thus, the Lewis formula, with the use of Tables 4 and 5, can be readily solved to determine the horsepower loads a nylon gear will take, based on the strength of a single tooth. It should be noted that the Lewis formula was originally derived for rigid metal gears where slight inaccuracies of tooth form and spacing create high dynamic loads, which have to be carried by a single tooth. However, the resiliency of nylon may allow contact of two or more teeth

Table 4—Safe Working Stress of Nylon at Indicated Pitch Line Velocities

PLV, Ft per Min	Nylon FM-10001 SWS
100	4500
150	4071
200	3750
250	3500
400	3000
500	2786
800	2400
1000	2250
1500	2029
2000	1909
2500	1833
3000	1781
4000	1715

under load. Consequently, computation by the Lewis formula should be conservative.

Nylon gears, because of their toughness, abrasion resistance, close tolerances and low costs, are being widely used in industrial applications. A recent gear application is on the General Electric oscillating fan. The gear is a molded worm wheel and pinion which is molded in one piece. It replaces a two-piece steel pinion and laminated worm wheel. The worm wheel is a helical gear having a helix of 5 deg., 45 min. (right hand), 47 teeth, and a pitch diameter of 0.9841 in. The pinion has 15 teeth and a pitch diameter of 0.375 in. In operation, this gear rotates at a speed of 32 rpm, with a maximum torque of 6.75 in.-oz. Lifewear tests on this gear show it to be equal to the previously used steel and laminated gear. Quieter operation, in addition to a parts cost saving of 65%, has been obtained.

A noteworthy property of nylon is its ability to dampen mechanical vibrations with a consequent reduction of noise. This property is being utilized in sound recording and motion picture equipment. The conformability of nylon—the ability to deform slightly to absorb shock—makes this material the choice in gears and other applications where impact loading is encountered. This same property of conformability enables nylon gears to satisfactorily mesh with metal gears, and iron out any irregularity that may be present in gear teeth.

Table 5—Values of Form Factor Y in Lewis Formulas

No. of Teeth	Gear-Tooth System		
	14½-Deg Composite and Generated	20-Deg Full Depth	20-Deg Stub Tooth
10	0.056	0.064	0.083
11	0.061	0.072	0.092
12	0.067	0.078	0.099
13	0.071	0.083	0.103
14	0.075	0.088	0.108
15	0.078	0.092	0.111
16	0.081	0.094	0.115
17	0.084	0.096	0.117
18	0.086	0.098	0.120
19	0.088	0.100	0.123
20	0.090	0.102	0.125
21	0.092	0.104	0.127
22	0.093	0.105	0.128
23	0.094	0.106	0.130
24	0.096	0.107	0.131
25	0.097	0.108	0.133
26	0.098	0.110	0.135
28	0.100	0.113	0.138
30	0.101	0.114	0.139
35	0.105	0.120	0.143
40	0.107	0.124	0.146
50	0.110	0.130	0.151
60	0.113	0.134	0.154
75	0.115	0.138	0.158
100	0.117	0.142	0.161
150	0.119	0.146	0.165
Rack	0.124	0.154	0.175

Other Applications

A number of miscellaneous machine parts are now being made of nylon, mainly because of its ability to be molded into intricate shapes with close tolerances. Bearing cages for a helicopter transmission are one example. A nylon connecting rod in an electric shaver provides the required toughness, resiliency and light weight. Lubrication is, of course, no problem with nylon. An injection molded counting dial replaced three hardened steel parts on a calculating machine. Cams and ratchets on the same machines also showed savings and gave better performance. The cam was produced in one production step in nylon, compared to 20 with steel.

Resistance to heat, toughness of thin sections, and translucency were the important factors in choosing nylon for light bulb-housings. A bulb is placed inside the housing and the assembly is then used to illuminate the inside basket of the G-E automatic washing machine. When the machine is in action, the bulb illuminates the washing machine basket. This feature has overcome the housewife's dilemma of leaving behind small articles in the basket, especially when the machine is located in cellars and dark areas.

A 15-w, 120-v bulb, as well as an aluminum deflector, is placed inside this nylon housing. Although the aluminum deflector helps to dissipate heat generated by the bulb, temperatures of 250 F are reached on the outside of the housing. All other plastic materials evaluated for the application, other than nylon, were badly distorted at operating temperatures. Wall thickness of the tube is 0.040 in., which provides ample strength and permits rapid dissipation of heat from the nylon. The outside of this housing comes in contact with water and washing detergents at temperatures of 70 to 190 F.

A drain hose elbow, made of nylon, carries discharge water away from the washing machine. The piece replaces a chromium plated copper elbow, and provides the user with a parts cost saving of 35%. The elbow carries water at temperatures up to 195 F.

The tremendous potential for molded nylon has only recently been realized. Nylon has also been successfully used in such industrial applications as coil forms pulleys, screws, valve seats, washers, pump impellers, hydraulic needles, and in countless other places where its toughness, abrasion resistance, strength in thin sections, and chemical resistance has made it an outstanding industrial plastic material.

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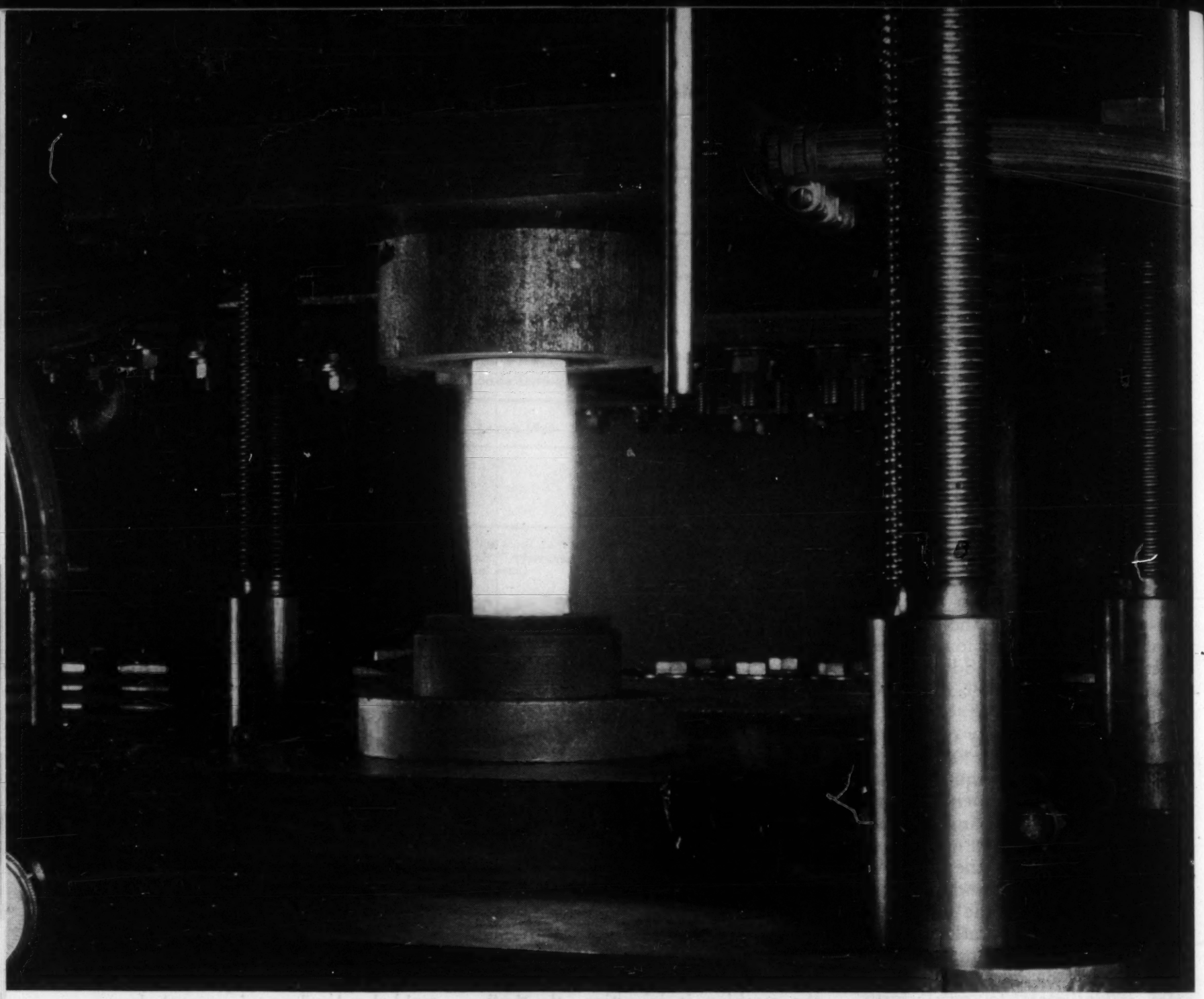


A carbide bushing being hot pressed by the hot molding method.

Tungsten carbide dies and shaped pieces, heavy metal products, and high temperature alloy parts are a few of the recent . . . .

Practical Applications of Hot Pressing

by **JEROME F. KUZMICK**, Consultant in Powder Metallurgy and President, Welded Carbide Tool Co.

● THE SIMULTANEOUS application of pressure and heat to metal powders—hot pressing—has for a number of years attracted the attention of powder metallurgists. The continuing interest in hot pressing is largely due to the fact that the method has demonstrated the following advantages:

1. The pressure required for hot molding metal powders is considerably lower than is normally used for cold pressing.

2. It is possible to hot press metal powders to solid density in one operation without sintering.

3. The properties of hot pressed alloys are similar to those of hot forged, or cold worked annealed materials.

On the other hand, there are some difficulties involved, such as:

1. Finding a suitable die material to withstand the elevated temperatures, which generally are about the same as the sintering temperature.

2. Finding rapid heating methods

for the metal powder and protecting against oxidation.

3. Prevention of welding of the compact to the die as a result of hot pressing.

4. Obtaining a rapid enough cycle to make the process practical.

There are two principal hot pressing methods. In the method known as hot forging, normally cold pressed and sintered parts are removed hot from the sintering furnace and subjected to a forging operation, usually in water-cooled steel dies. In the other method, known as hot molding, pressing and sintering are simultaneously performed in one operation. The charge in the die may be the metal powder itself, or it may be a preform which has previously been molded by the usual cold pressing method. This article is concerned only with applications of the second method, hot molding.

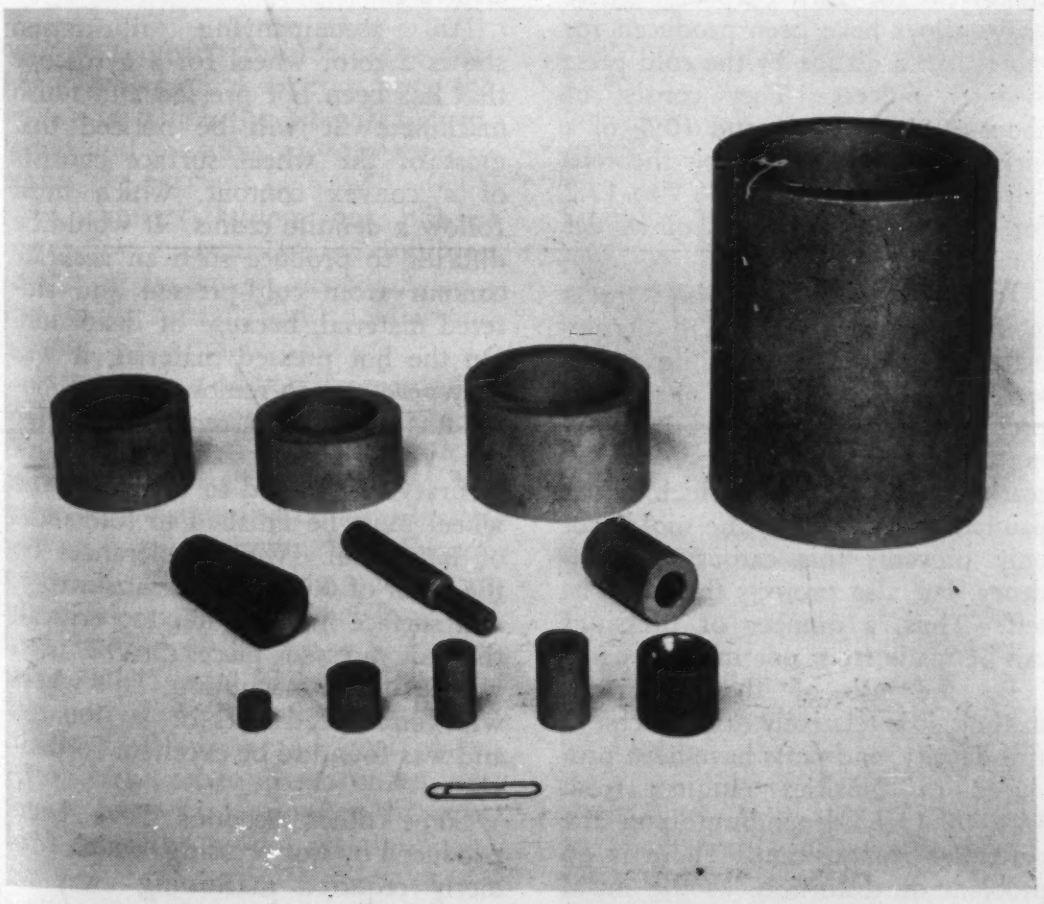
Up to the present time no process has been worked out and put into operation for rapidly producing hot pressed metal powder mechanical parts on a commercial scale. However, hot pressing has been successfully applied to a number of applications involving costly materials, where no other method would give the desired results, and where cost is secondary.

Tungsten Carbide Dies and Shaped Pieces

The hot molding method for the manufacture of large tungsten carbide sections has been in use for some time. Improvements in technique have now made it practical to apply this method to a number of sizes and shapes of tungsten carbide pieces.

In this method graphite molds are produced by machining from graphite bar stock. In most cases the molds are the so-called "closing type"; that is, they are so dimensioned that the proper size piece has been produced when the plungers have compressed the carbide mixture so that the outer ends of the plungers are flush with the upper and lower surfaces of the die barrel.

From the known density of the end product, the weight of the desired carbide mixture is calculated and poured into the die cavity. The plungers are lightly pressed into the cavity, and the mold positioned in the hot press. The piece is hot pressed at relatively low pressure on the order of 1000 psi. The final temperature is similar to the temperature used for sintering cold-pressed carbide, usually about 2450 to 2650 F, depending upon the cobalt content.



Here are some typical hot pressed tungsten carbide pieces.

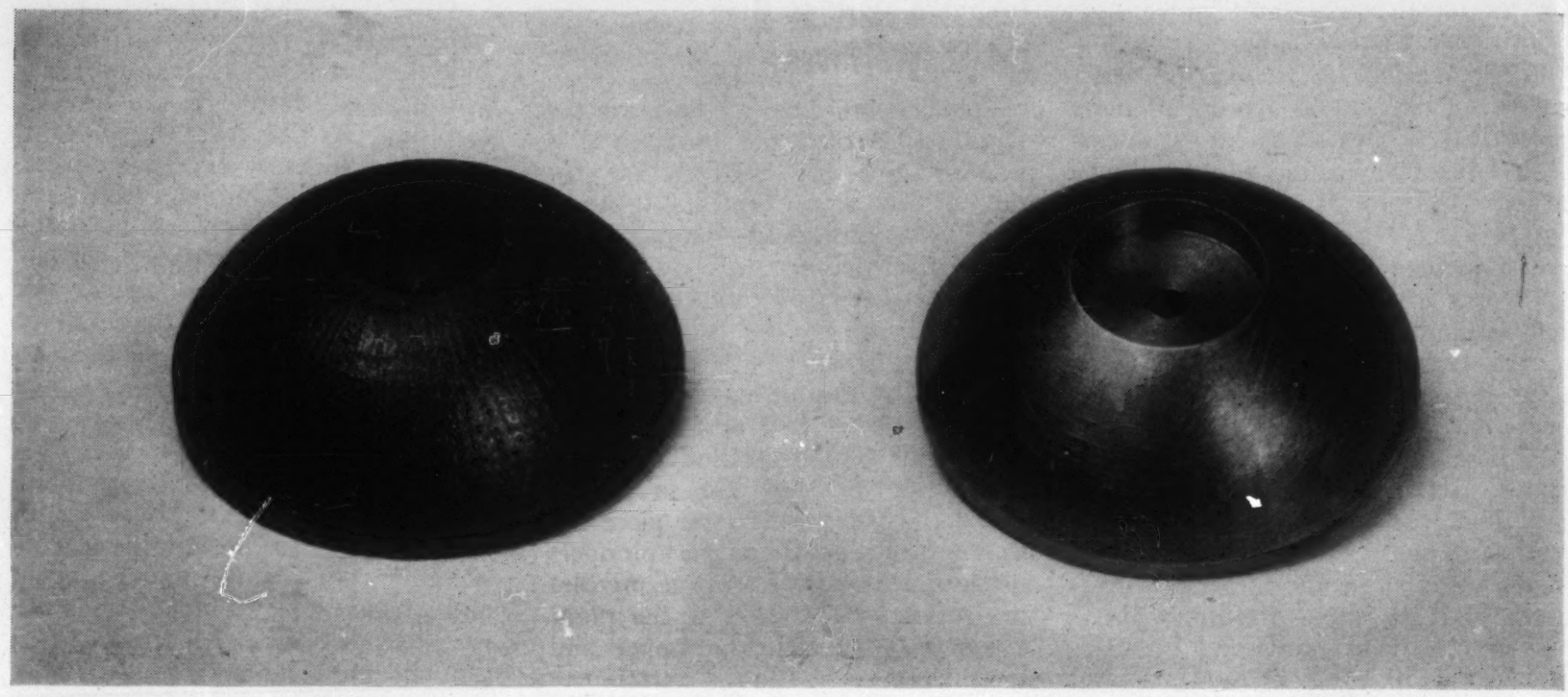
Care must be exercised not to underpress or overpress. If the carbide mixture is not fully compressed, porosity will result in the finished carbide. On the other hand, overpressing will cause excessive squeezing out of cobalt binder, causing improper binder content, and local segregation of cobalt, which again results in porosity or soft spots. For this reason, even with closing-type molds, the compression of the carbide charge is carefully measured with dial indicators.

Unfortunately, in most cases it is impossible to salvage the graphite mold after one use. However, in many cases this procedure is economical. On plain round cylinders and bushings, standard graphite round bar stock can be purchased in a number of sizes, so that often only simple cutting-off and drilling operations are required to produce the desired mold. On small pieces it is possible to use multicavity molds in which several pieces are made simultaneously. For shaped pieces, it is often easier to machine a graphite mold than it is to machine pre-sintered cold pressed carbide, which is fragile and must be handled and machined with extreme care.

One of the advantages of hot-pressed carbide is the absence of sinter shrinkage. It is well-known that cold pressed carbide can shrink as much as 18% linealy or 50% by volume during the sintering operation. Thus, it is a difficult problem to avoid distortion on odd-shaped pieces or long thin-walled sections which may vary in density as cold pressed. On the other hand, the hot pressed carbide completely fills the mold cavity as it compresses, and the dimensions are those of the mold cavity.

Repressed Tungsten Carbide Dies—When carbide drawing dies have been worn beyond bore tolerance, it has been the customary practice to grind out the i.d., if possible, to the next larger size. As the size increases, the difficulty of this practice also increases, because the next larger size bore may require removal of a considerable amount of carbide. The bore cannot be increased very much before the die wall becomes too thin, and a sizable piece of tungsten carbide must be discarded.

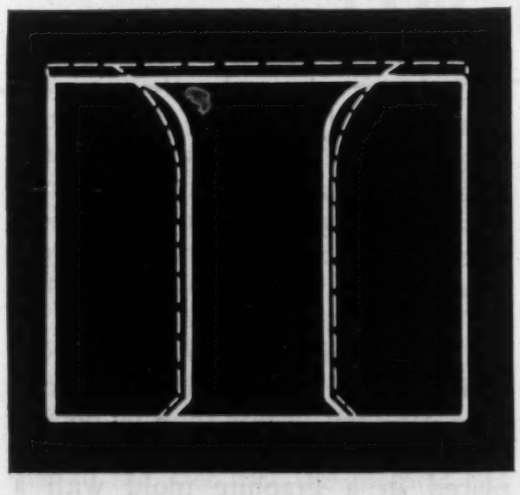
Thousands of drawing dies have been salvaged in our shop by hot repressing. In this method, the die is placed in a graphite mold with a core of the desired diameter, less several thousandths grinding allow-



A rotor wheel for a gyroscope composed of Densalloy and produced by hot pressing. Left, as hot pressed; right, after finish machining.

ance. The die is hot pressed in the mold, and, as the carbide becomes plastic, it is compressed slightly, filling in the bore and losing a little in height (see accompanying figure). As a result of this technique, carbide is taken out of the height, which is not critical, and transferred to fill in the bore, which is the critical dimension. The graphite molds can be used several times, and the surface of the carbide die retains a fairly good finish. As a result, only a few thousandths need be ground off the bore surface to produce a high degree of accuracy and finish.

One large concern which uses many dies for drawing tubing has had the same dies repressed three times, and they are still in use. Also, the die life after repressing has increased appreciably over that obtained on the original cold pressed and sintered die. It is believed that this is due to the elimination of microporosity by the hot repressing operation.



A carbide drawing die before (dotted lines) and after (solid lines) repressing.

Hot Pressed Heavy Metal Products

A recent development at our company is the use of the hot press process for the production of heavy metals. It is believed that this is the first time that hot pressing has been employed for this purpose. These heavy alloys have been produced for more than a decade by the cold press —sinter process. They consist of about 90% tungsten, and 10% of a nickel-copper binder. Their theoretical density ranges from 16.5 to 17.2 for the usual percentages of binder employed.

In developing the hot press method for producing high density materials, the usual graphite molds were used. However, one of the first problems encountered was carburizing of the tungsten by the mold. A coating was developed, which, when painted or sprayed on the mold, not only prevents this carburizing tendency, but also protects the mold itself. Thus, a number of pressings can be made from one mold.

By the use of the hot press method, it is relatively easy to achieve full density, and parts have been produced to densities ranging from 16.5 to 17.1, depending upon the particular composition. There is no problem of distortion, as the metal under heat and pressure completely fills the mold. The structure of the hot pressed heavy alloy is much finer in crystal size than that of its cold presssed—sintered—counterpart, because the hot press cycle is relatively fast, whereas sintering to high density requires sufficient time for considerable growth in the crystal size of the tungsten. The machinability of the hot pressed alloy is considerably better than that of the sintered material, and it is believed that this is due to the difference in crystal structure.

An accompanying illustration shows a rotor wheel for a gyroscope that has been hot pressed and finish machined. It will be noticed that most of the wheel surface consists of a convex contour, which must follow a definite radius. It would be difficult to produce such an accurate contour from cold-pressed and sintered material, because of distortion. On the hot pressed material, it was only necessary to remove a few thousandths of the tungsten alloy to give the required surface finish and accuracy. In regard to the latter, the wheel must be finished to tolerances of 0.0001 in. Where tolerances on the order of 0.005 in. are satisfactory, and surface finish is not too critical, the hot pressed piece can be used without finish machining. This wheel withstood speed tests of 30,000 rps and was found to be excellent for balance.

Some other sections have been produced by hot pressing, which formerly required machining away as much as 50% of the tungsten alloy

from the sintered piece to produce the required contour. It is anticipated that expansion of hot pressed heavy metal applications will result in considerable savings in tungsten scrap and machining time.

Other Applications

Some very interesting applications of the hot press technique are being made in the diamond dressing, grinding and drilling fields. A good example is diamond mining bits, for exploratory, blast hole and oil well drilling. Many such bits were formerly—and in some cases still are—produced by casting alloys such as beryllium-copper around diamonds. However, when drilling tough and broken geologic formations, such bits may show rapid metal wear and erosion, resulting in the diamonds being lost before they have been worn to the extent of their useful life. Some bits are also made with a cold-pressed and sintered metal matrix. For most applications, however, the manufacturers have been going to the hot press method. They are producing metal matrices which resist wear and erosion, and retain the diamonds sufficiently well, so that they are salvaged and re-used in new bits after their exposed points have been worn smooth.

The diamond bits are being produced with a variety of metal matrices, ranging in hardness from about 20 Rockwell C up to the full hardness of tungsten carbide. The particular matrix used depends upon the service to which the bit will be subjected and the type of formation in which the bit will be used.

In similar fashion, hot pressed metal powder matrices are employed in the production of diamond dressing tools, metal bonded diamond wheels, and similar products.

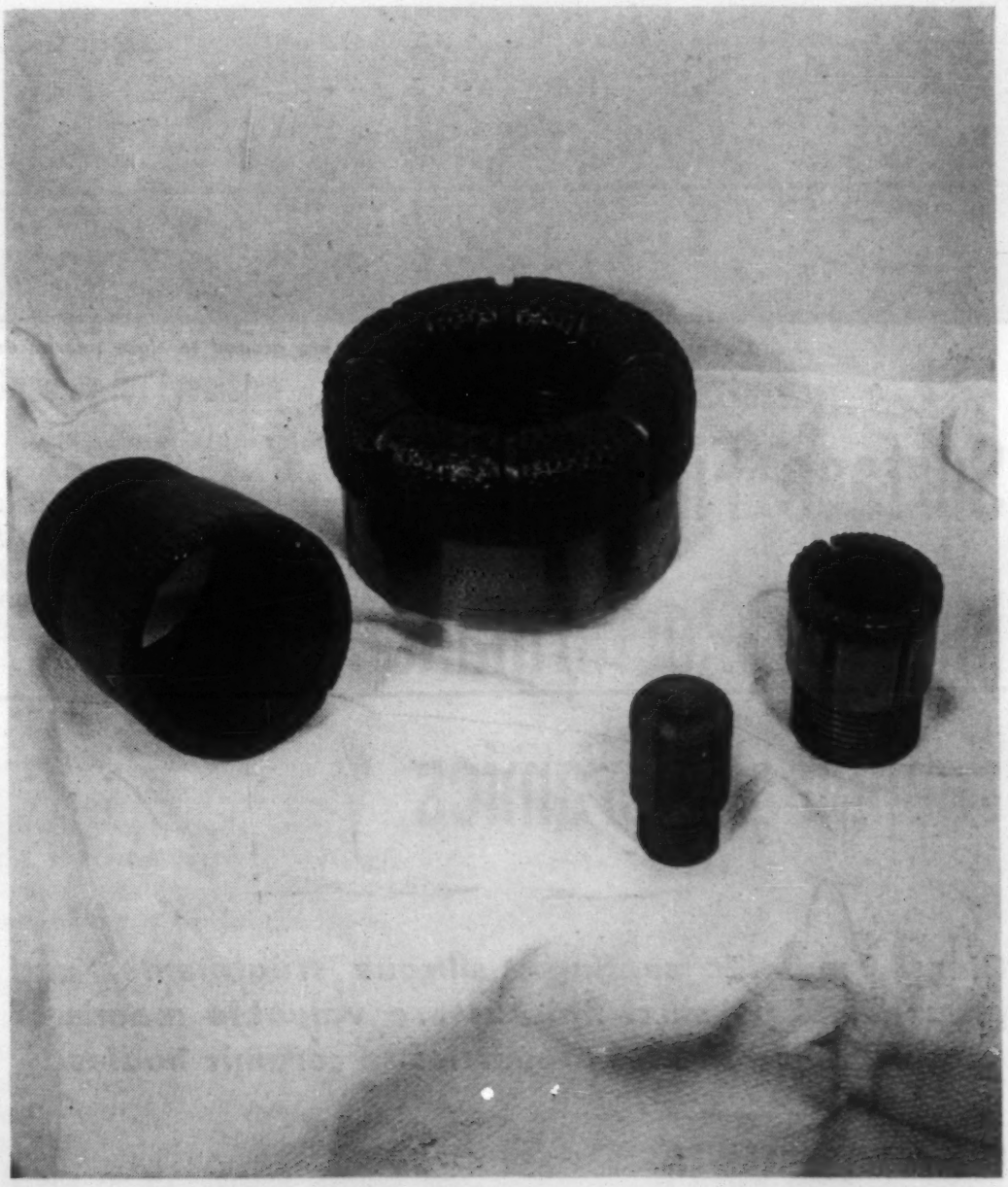
Hot pressing of beryllium is being accomplished, and the properties compare favorably with vacuum cast extruded material. A form of hot pressing, or sintering under pressure, is used in producing metallic friction materials. The friction surface or wafer is welded to a steel back and brought to final density by being sintered in a special bell type furnace, which applies pressure to a stock of the friction wafers and steel plates. Also, large silver base contact materials have for a number of years been produced by hot pressing.

One of the virgin fields of research is that involving high temperature alloy or metal-ceramic materials. In a program with which the author has been associated, a method was developed whereby a hot pressed alloy was prepared which showed the same high temperature stress-rupture value as a forging of the same alloy. Subsequently, advantage of the powder metal process was taken, whereby certain materials and grain orientation were introduced which are impossible to obtain in material that begins as a cast ingot. In a short time this technique resulted in a modified alloy which showed over five times the stress-rupture life at high temperatures than that of the forged material.

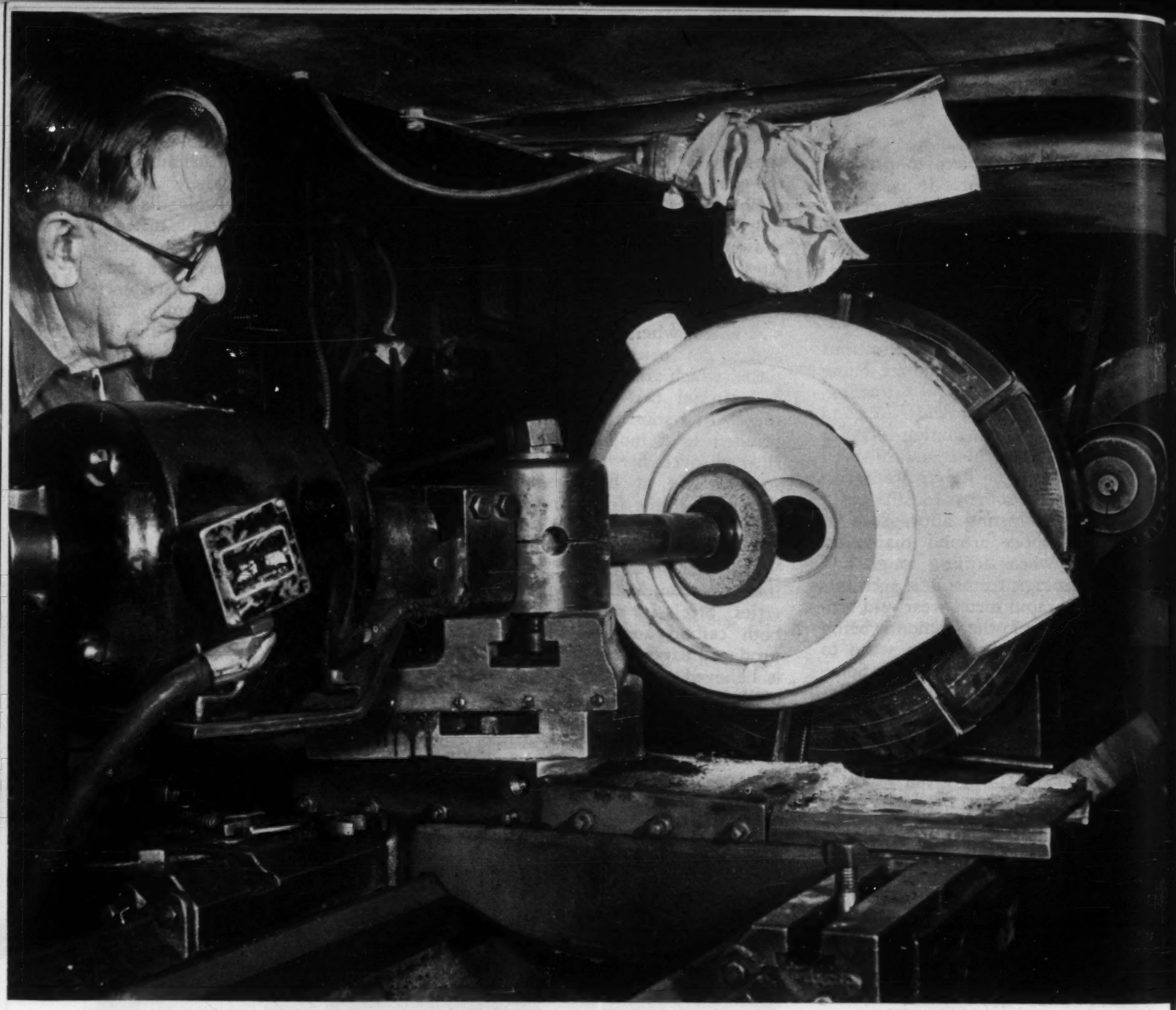
Since then, a number of alloys and materials have been developed by the hot-press method. Many of these show unusual mechanical properties. Steels for more ordinary uses, both carbon and alloy, have been produced experimentally. In time, it is believed that these steels will be used for the production of dies for molding, drawing, etc., with considerable savings in machining and finishing. However, there is still the problem of a suitable die material. Every type of ceramic material available, as well as high-temperature alloys, and cermets have been tried. Another approach that shows considerable promise involves the use of a cheap, discardable die. In mass production, the cost of such a die should be measurable in cents rather than dollars.

Thus, while a hot pressed 10¢ gear cannot yet be visualized, the continued development of the hot press technique will result in time in a fine array of products, complementing the excellent variety of parts continually being developed by the normal cold pressing and sintering method.

Adapted from a paper delivered at the Eighth Annual Meeting of the Metal Powder Assn., Apr. 1952.



Diamond mining bits is another interesting application of the hot press technique.



Ceramic pump housings and impeller are ground to close tolerances. (U. S. Stoneware Co.)

Surface Finishes Improve Performance of Technical Ceramics

Glazes, metallic coatings, silicone treatments, and ground and polished finishes are valuable means of contributing special properties to ceramic bodies.

by DR. HANS THURNAUER,

Vice President, Director of Research, American Lava Corp.

● THE RIGHT SURFACE FINISH on a ceramic can often improve its service performance to a significant extent. In this respect, ceramics are no different from other materials. Surface finishes on metals, for example, contribute just about as much to their performance as the qualities of the metal itself. Thus, the acid resistance of a stainless steel sheet does not depend only on the chemical composition of the metal, but also on the surface polish; the properties of aluminum are fundamentally changed by anodic coatings; and vitreous enamel coatings on cast iron and steel increase the corrosion resistance and make the surfaces easier to clean. Likewise, glazes in ceramics can provide increased smoothness and improved electrical properties; moisture repellent treatments can prevent fungus growth; ground and/or polished finishes can improve accuracy and performance; and metallic coat-

ings can contribute properties which the ceramic body itself does not have.

Ceramic Glazes

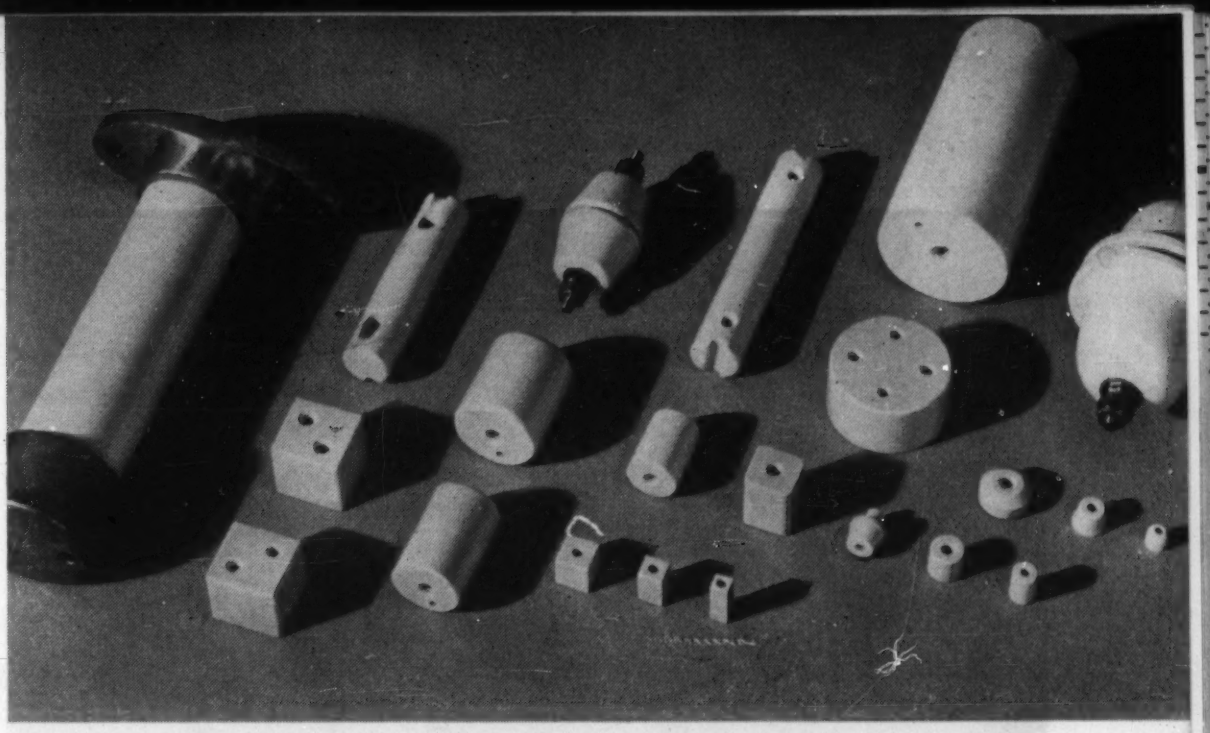
The best known and most widely used finish on ceramics is a glaze. A glaze is essentially a glass coating fused to the ceramic surface. A suspension of powdered glaze ingredients in water (the slip) is applied to the surface of the ceramic by spraying or dipping. This layer is then fused into a glass by firing. A wide variety of compositions, with properties to suit special applications, are available.

A good glaze should have a coefficient of thermal expansion slightly smaller than the coefficient of the body ceramic. If there is too great a difference between the coefficients of expansion, either the body or the glaze may crack after firing. The surface crazing cracks on low grade ceramic products are caused by using a glaze that contracts too much as it cools. When the glaze has a slightly lower coefficient than the body, however, the glaze is in compression and the body is in tension when the part cools after firing. This surface compression makes the part stronger.

Glazes are used on technical ceramics for various purposes in different applications. Unglazed ceramics are relatively rough and collect dirt. The smooth surface of a glaze does not absorb as much water as an unglazed surface. Outdoor electrical insulators are typical glazed parts. Noise-free high tension suspension insulators carry a semi-conducting glaze to prevent corona between the metal cap and the insulator. The corona starting voltage and the flashover voltage of ceramic bushings in electronic equipment can also be raised by semi-conducting glazes. On the other hand, glazes with low dielectric losses improve high frequency insulators, especially under humid conditions. The rating of a ceramic material (JAN-I-10 Specifications) can be improved a full grade by a low loss glaze.

Moisture Repellent Treatments

Silicone moisture-repellent coatings have helped to solve one problem sometimes met with ceramics. Under extremely humid conditions, glazes alone may not give enough protection against moisture. When a plane dives into a cloud, a moisture film may collect on a glazed insulator and short it out. Silicone coatings prevent this. Both glazed and unglazed ceramics are moisture proofed by exposing them to silicone vapor or by immersing them in silicone oils and baking. The invisible film that it formed repels moisture.



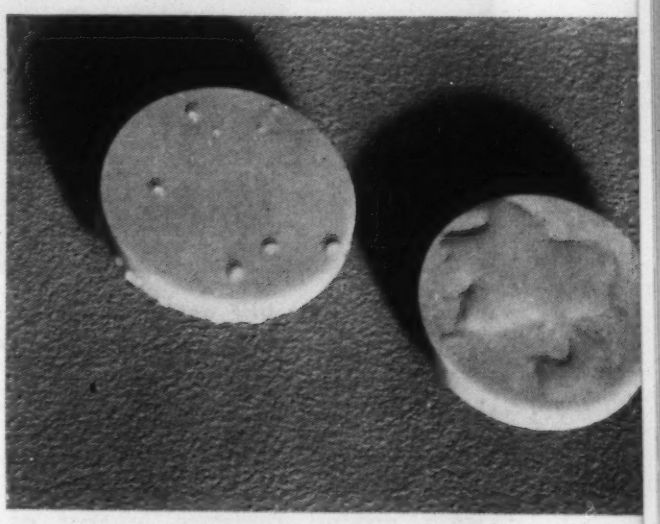
Ceramic insulators for high frequency applications carry low dielectric loss glaze. (American Lava Corp.)

Silicones have replaced moisture-repellent waxes. The disadvantage of waxes is that they are excellent nutrition beds for tropical fungi. Some of these fungi form thread-like covers over insulators. These covers become laden with moisture and conduct electricity. Fungicides in the waxes prevent fungus growth on insulators, and even protect other components near the insulators. Although these fungicide waxes are still used on ceramic insulators, they are being replaced to a large extent by silicone coatings.

Grinding for Precision

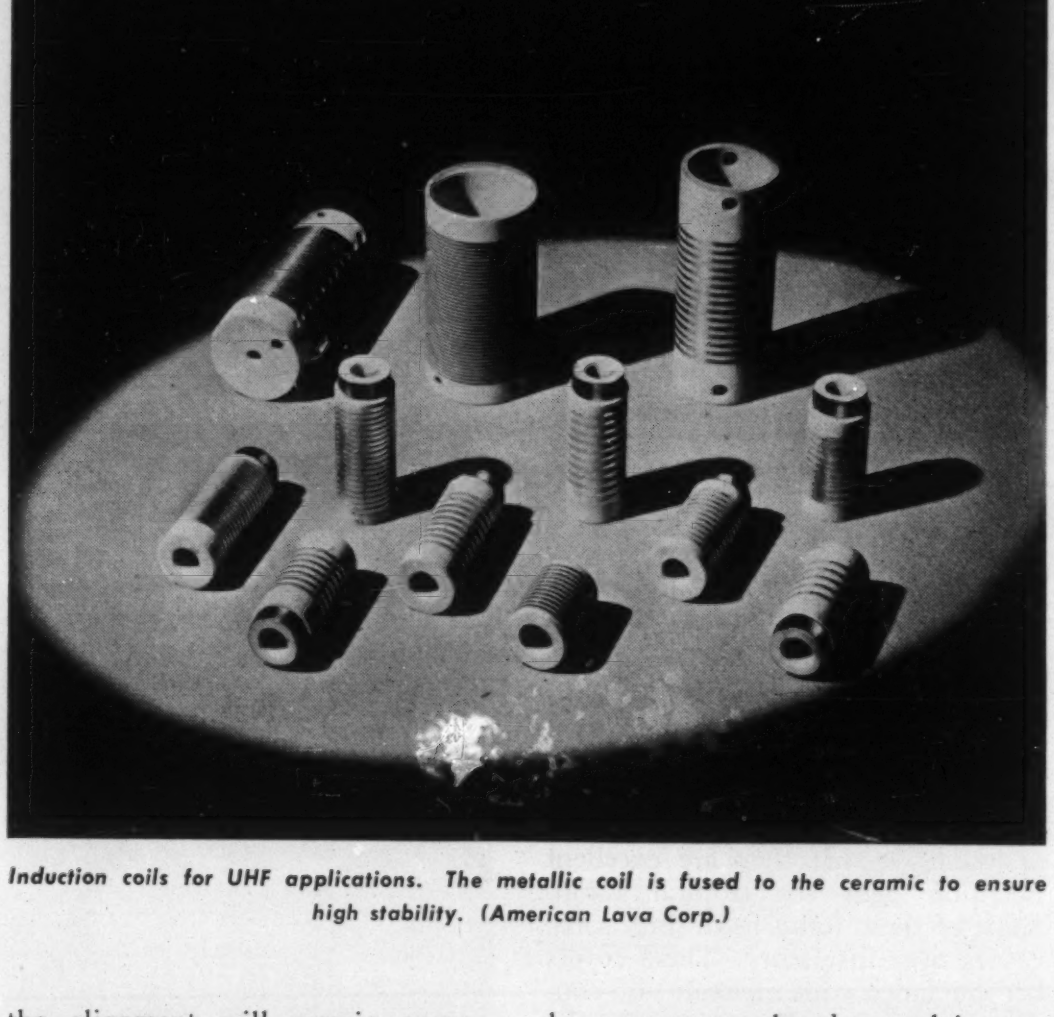
Controlling the dimensions of ceramic products has always been a problem, since ceramics undergo high shrinkage after firing. Where high precision is required, machining after firing becomes necessary. Because of the hardness and stone-like nature of the material, grinding, lapping or honing are the only ways to machine ceramics successfully after firing. Modern high-speed grinding equipment is used. Certain grinding operations, such as centerless grinding of rods and tubes and surface grinding of plates, can be carried out quite economically.

Precision ground ceramic rods are used for shafts in tuning air capacitors. In order to assure perfect alignment of the rotor against the stator plates, these shafts are ground perfectly straight and to a tolerance of 0.0001 in. on the diameter. The rigidity of the ceramic assures that



The ceramic disk that has been treated with a silicone repels water, forming droplets. The water spreads over the untreated disk. (American Lava Corp.)

Pin type high tension porcelain insulator with conducting glaze on the upper part to prevent corona.



Induction coils for UHF applications. The metallic coil is fused to the ceramic to ensure high stability. (American Lava Corp.)

the alignment will remain permanent. Another application of precision ground ceramics is that of alumina porcelains for gages. When ground into plug gages, they outwear tool steel gages many times.

Some of the vitrified finely grained ceramic bodies can be finished with the same precision as metals. Equally good surface finishes can be accomplished. Flat ground ceramic surface reference plates for gaging metal parts are finished flat within a few light bands, and the original flatness is not disturbed by impact or rough handling. Actual wear is the only problem.

More difficult and time consuming are honing or lapping of holes or inside diameters of tubes. Holes lapped with diamond powder to a precision of 0.001 in. or less are used for wire drawing dies and extrusion dies for carbon and lead. Ground ceramic-to-ceramic joints give a water-proof fit and are extensively used in chemical stone ware.

Polished Ceramics

The textile industry requires abrasive resistant materials with smooth surface finishes for the manufacture of yarns. Some of the less abrasive fibers, like wool, silk or cotton, can be spun over glazed porcelain, enamel or chromium plated surfaces. Synthetic fibers loaded with abrasive delustering powders, on the other hand, exert such a cutting action that they wear out ordinary metals or glazes in a very short time. Highly polished hard ceramics made of titania or alumina have excellent wear resistance and are used under the most severe conditions. It is possible to produce various types of surface finishes on these ceramics, and thus control the pull between the yarn and the guide. These various surface finishes can be produced by grinding, polish tumbling or buffing. The grit of the grinding medium is one of the determining factors of the ultimate surface finish.

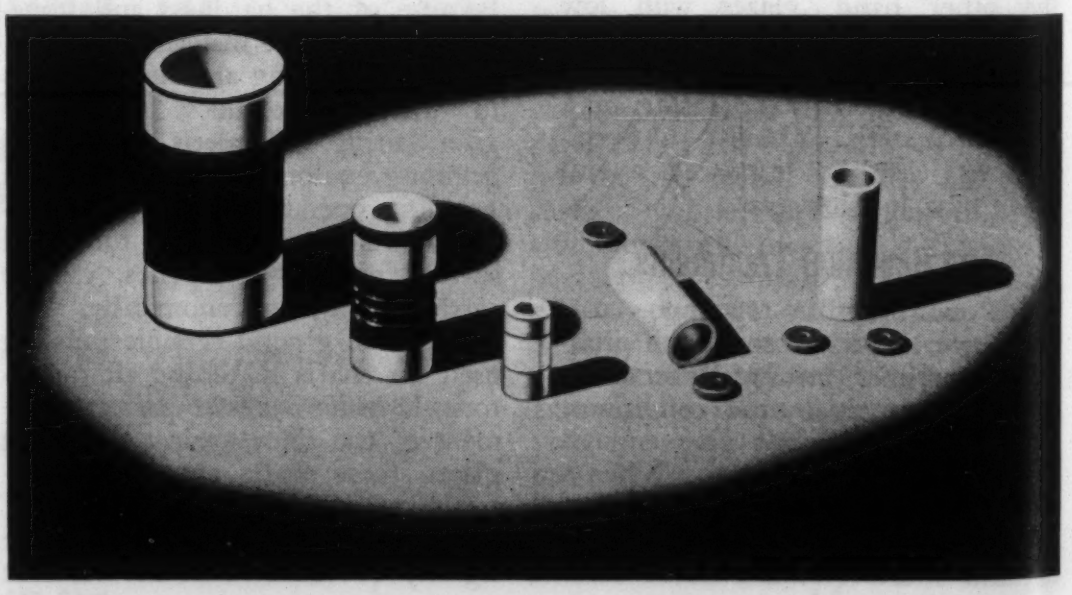
The polishing of ceramics is an interesting process and more of an art than a science. Various theories on the polishing of metals have been developed, and to some extent applied also to the polishing of ceramics. Polishing is not just a slow grinding process, but certain surface properties of the material are altered by the polishing process. It has been theorized that heat and pressure cause extremely fine particles on the surface to flow into equally small recesses, where they solidify into an undercooled liquid of amorphous structure. Following this theory, pressure polishing is quite different from grinding and can be accomplished only when the melting point of the abrasive material is higher than that of the body being polished.

It has been pointed out that similar conditions exist in the polishing of non-metals. Quartz, for instance, which has a hardness of 7, and a melting point of 3110 F, can be polished with tin oxide, which has a hardness of 4, but a melting point above 3270 F.

Controlled Surface Roughness

Certain roughness effects on ceramic surfaces can be obtained by sand blasting, etching or tumbling in coarse, abrasive compounds such as silicon carbide grain. Roughened surfaces aid the adhesion of coatings. For instance, carbon deposited resistor coatings adhere better to ceramic

Metallized ceramic cases for hermetically sealing precision resistors and capacitors. (American Lava Corp.)



surfaces if these have been treated by one of the above methods. Metallic coatings on ceramics, produced by spraying, also adhere better on a roughened, sand blasted surface.

Metallic Coatings

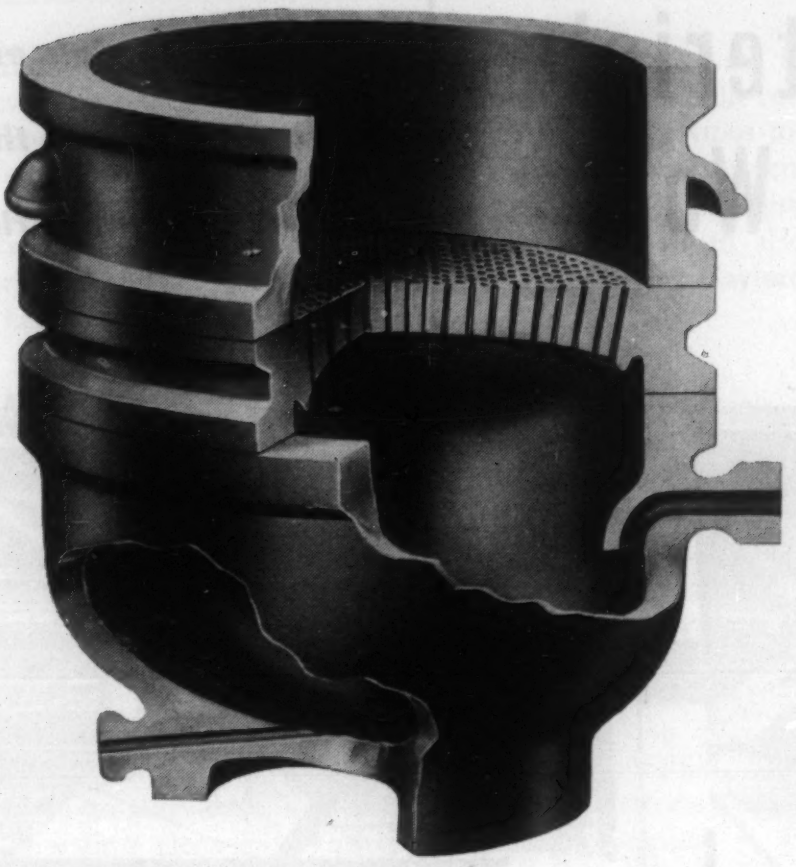
The joining of ceramic bodies to metal is a problem frequently encountered. In many instances, mechanical joints can be made by compressing a metallic ring around a ceramic rod, or by riveting eyelets into ceramics. For joints which must be vacuum or gas tight, temporary seals with gaskets or sealing compounds are useful. The best hermetic seals, however, are made by applying metallic layers or coatings to the ceramic surface, so that they form an integral unit with the ceramic. Such coatings can be soldered and hermetically sealed to metals.

The art of metallizing ceramics is old and dates back to the decoration of pottery in ancient times. Noble metals, gold, silver or platinum are mostly used for decorative purposes, because these withstand the high firing temperatures without oxidation. The powdered metals are mixed with a small amount of powdered glass and organic carriers, oils or resins, painted to the surface of the ceramic, and fused at temperatures at which the glass flux fuses, between 1380 and 1560 F.

Fired-on silver coatings fulfill a number of useful functions for ceramic electronic components. Ceramic capacitors are made of a ceramic dielectric plate or tube having a high dielectric constant, with fired-on silver electrodes and leads soldered directly to the silver layers. A perfectly rigid unit results because the electrodes are permanently attached to the dielectric and form an integral part with it.

Inductors of equally high stability are formed by metallizing spirals to the surface of ceramic cylinders or plates. Expansion and contraction of the metal with temperature is restrained by the bond to the ceramic surface.

Effective shielding of electronic components can be accomplished by housing them in a ceramic case, fully metallized on one surface to prevent radiation. Transformer housings have been designed to take advantage of this feature. Complete electronic circuits assemblies are made on vitreous steatite ceramic base plates, by printing wiring patterns on the surface, using the same types of silver paints and firing the pattern to the ceramic.



The filter support section of this suction filter, the upper section and the lower section are ground and lapped to form a seal. (U. S. Stoneware Co.)

Metallizing ceramic surfaces and soldering metals to such coatings is also an effective method to make hermetic seals. For soft solder seals, the same type of silver coatings as described for capacitor electrodes and induction coils are applied. These coatings can be soldered directly, but it is advisable to protect the silver by electroplating with copper and tin. This prevents the silver from dissolving in the solder and assures uniform wetting with solder. Soft solder joints of this type are used for hermetically sealing of ceramic terminals of motors, capacitors, rectifiers and similar electronic components. In some cases, such seals are accomplished between two metallized ceramic parts, in others between one metallized ceramic part and a fully metallic component.

Metal - ceramic combinations for high vacuum seals, like those used for electron tubes with ceramic envelopes, must be of the hard soldering type. In such cases, the metallic coatings on the ceramic must have a high melting temperature, and the silver-glass coatings are not suitable.

Hard solder ceramic seals of various types were first developed in Germany. Since World War II they have been perfected and are commercially applied in this country. They are more difficult to make and conditions have to be carefully controlled to obtain satisfactory seals. The ceramic must be chosen with respect to coefficient of expansion, density, freedom from gassing under vacuum or in hydrogen atmosphere, and low dielectric loss. The joints between ceramic and metal must fit closely and must be ground to tolerances of 0.001 in. The selection of metallic coatings for hard soldering is more varied, because the metals are bonded under a protective atmosphere or under vacuum to prevent oxidation.

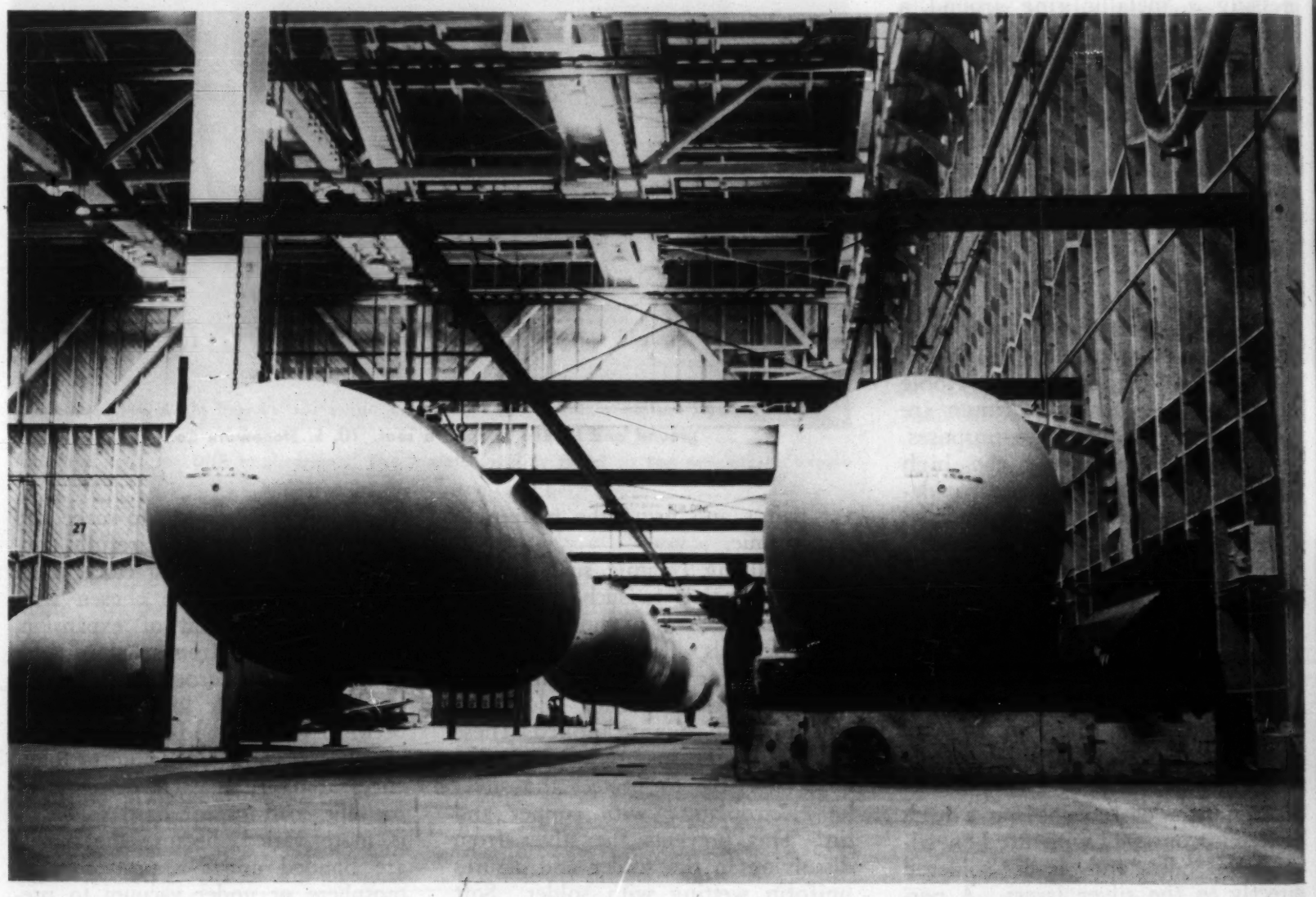
Coatings for silver soldering or brazing were originally made by applying iron-molybdenum mixtures, and firing these to the ceramic in hydrogen atmosphere. This method has been modified and improved by using molybdenum-manganese powders. Other methods use titanium-hydride or zirconium-hydride as sealing medium. The hydride sealing method has the advantage of the seal being accomplished in one firing under vacuum, without previous sintering of the metal to the ceramic. Hard soldered metal-ceramic seals are still in their infancy, but they show great promise for new designs of vacuum tubes, especially miniature tubes, x-ray tubes and other types of seals which have to withstand brazing or silver soldering.

Materials at Work

Here is materials engineering in action . . .

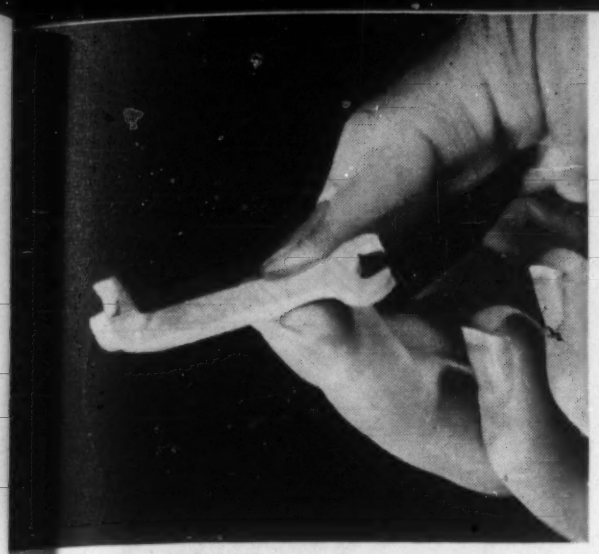
New materials in their intended uses . . .

Older, basic materials in new applications . . .

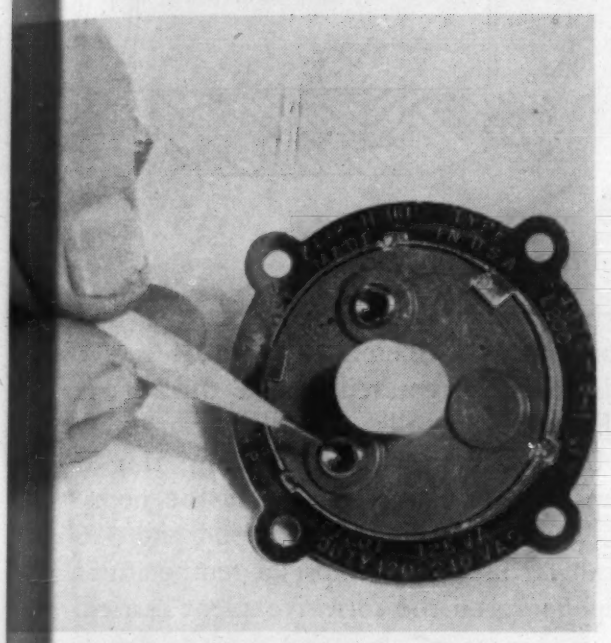


ALUMINUM FUEL TANKS The world's fastest known bomber, the new Boeing B-47B, has increased its combat range considerably through installation of Ryan external fuel tanks, the largest ever mounted on an airplane. The huge streamlined tanks, capacity of which remains secret, are under construction in mass quantities at Ryan Aeronautical Co. Suspended one under each wing, between the tip and inboard jet engine pods, the tanks will enable the B-47B's to complete long-range missions, carrying more than 20,000 lb of bombs.

More than 30,000 electric spot welds are employed in each tank. All circumferential joints are closed with two rows of spot welds and one row of seam welding to attain a gas-tight seam. The single longitudinal seam, which runs through the individual tank sections, is fusion-welded on automatic heliarc welding machines. This provides a strong, flat seam no thicker than the metal itself and does not require splice plates. The giant spot welding machines can squeeze aluminum alloy sheets together with 10,000-lb pressure, and can produce more than 200 spot welds per min, cramming nine of them into a running inch. Because of the difficulty of cleaning the metal, an alloy of aluminum without cladding, Ryan had to develop a new cleaning agent which removes all oxides with uniformity.



REINFORCED ALKYD WRENCH This miniature wrench is used for adjusting sensitive electronic equipment where delicate balances would be disturbed by a tool made of metal or other conductive material. Previous to the glass fiber-reinforced alkyd plastic, it was thought that only a metal wrench would have the necessary strength. Now, the strength and electrical property requirements have both been met by the alkyd material which also remains nonconductive after continued use. The part is molded by Gaylord Plastics, Inc., for Lear, Inc.



MICA-GLASS SWITCH BASE Bases for thermo-snap controls are being molded of G-E Mycalex by the Plastics Dept. of General Electric's Chemical Div. to assure satisfactory performance in a variety of applications requiring non-adjustable temperature controls. The controls are manufactured by the Spencer Thermostat Co. Operation is based on a thermal actuating disk.

Mycalex, an insulating material composed of a special glass and powdered mica, was specified for the thermostat base because of its high-temperature resistance (up to 700 F) and high-dielectric strength. By utilizing recently-perfected transfer molding techniques, metal inserts are molded in and the high-dimensional stability of Mycalex facilitates precision assembly of male contact points after molding. Recommended for applications which expose the thermostat to dirt, dust, lint, oil and high temperatures, Mycalex resists these deteriorating elements. The thermostats are supplied in a range of temperature differentials, and all types are available, with single-pole-double-throw or single-pole-single-throw contacts.

STAINLESS STEEL SWITCH ACTUATOR Precision miniature switches are now being manufactured that will open and close as many as 100 million times. This was made possible by a new type of alloy known as Armco 17-7 PH (Precipitation Hardening) stainless steel. Operating clearances in these switches are often critically small, and even a slight change in position of the actuator may render the switch useless. Drift characteristics of 17-7 PH stainless are reported to be superior to any other material tested. Switch life has also been greatly lengthened because of the flexure endurance of the metal. Another advantage is corrosion resistance, which further contributes to long, dependable service.

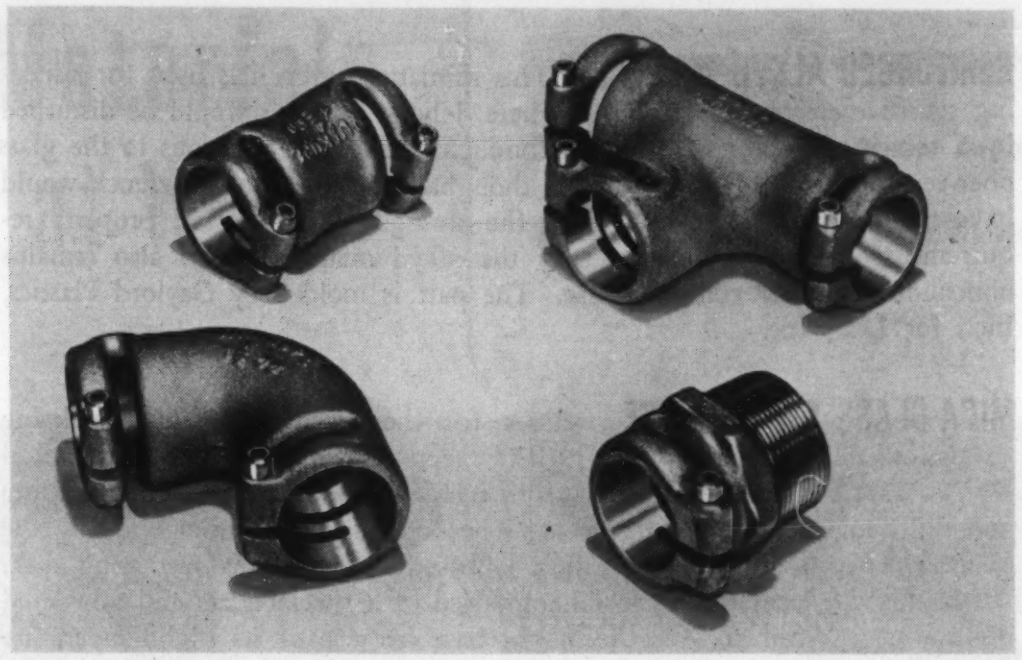
Some standard types of stainless steels, while durable, have poor spring characteristics when soft enough to form properly. They take a permanent set after relatively few operations. Other standard types of stainless with good spring characteristics will crack when severely worked. 17-7 PH stainless has solved these problems, according to the manufacturer, Micro Switch Div. of Minneapolis Honeywell Regulator Co.

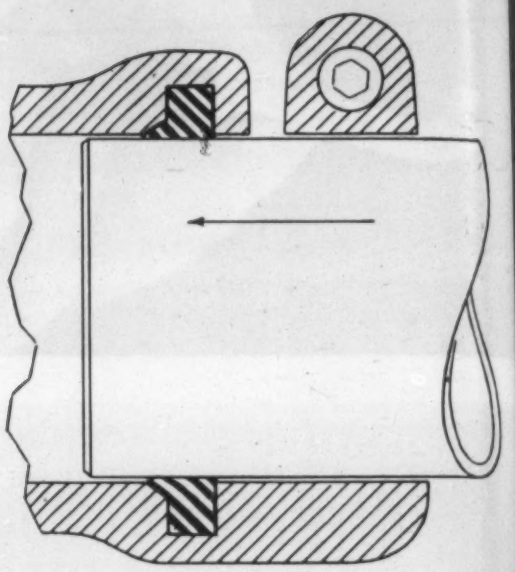
LEATHER AND RUBBER OIL SEAL A combination leather and rubber oil seal has been developed by the Allis Seal Corp., Chicago, for use in the track-laying wheels of the Army's medium tanks. The leather inner seal is coated with a Geon vinyl plastic latex to insure proper lubrication, and an outer seal of Hycar American rubber keeps out dirt and dust. Both Geon and Hycar are products of B. F. Goodrich Chemical Co.

This seal must stand up under the severest weather conditions and continue to operate perfectly in temperatures ranging from the arctics to the tropics. It is subjected to snow, salt-water, mud and sand.

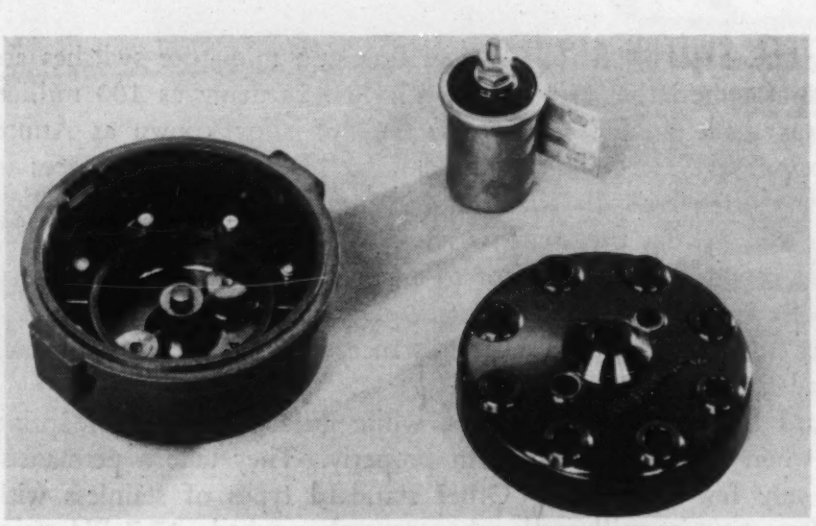
Not only is the sealing action improved, but the service life is lengthened by coating the leather with an oil and abrasion resistant Geon polyvinyl plastic latex. Geon adds body to the leather and helps it hold its shape as well as regulating the amount of oil used for lubrication. The coating decreases the porosity of the leather to desired point to regulate lubrication.

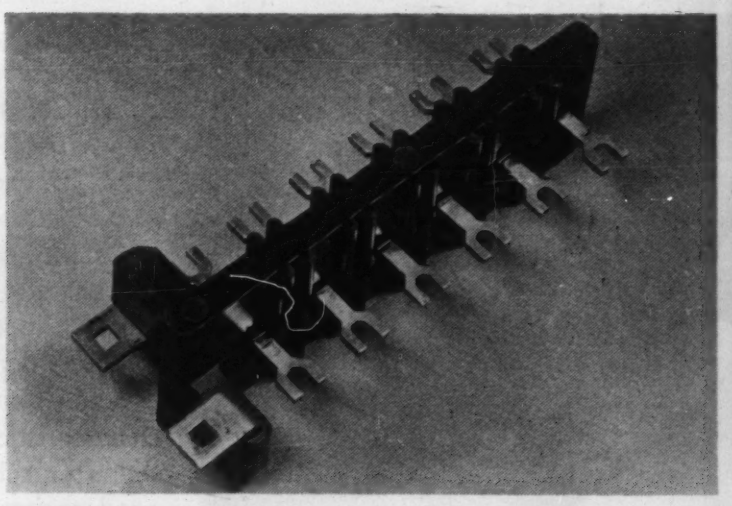
Materials at Work

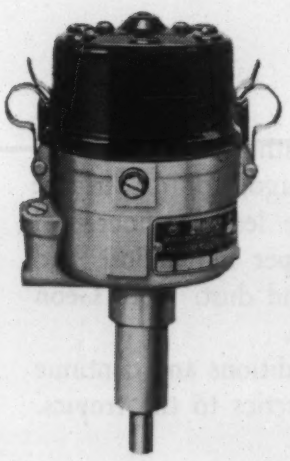




STAINLESS STEEL COUPLING A new stainless steel pipe coupling is designed to permit the use of less expensive, lighter-wall stainless steel tubing. The fittings are made by The Cooper Alloy Foundry Co. and are marketed by Peter A. Frasse and Co., Inc. under the name Quikupl. The couplings can be joined to tube or pipe without threading, flaring, sweat soldering, brazing or welding. The tube or pipe is simply cut to length, deburred and inserted in the fitting. The coupling is completed by tightening a small screw. Heavy pipe walls formerly required to take threads are not necessary. Elbows, tees, ells and other shapes are offered. Inside the fitting a Neoprene sealing ring is contained in a machined groove to provide the necessary squeeze fit. The fittings are made of 304 and 316 stainlesses and can be used at 150 psi at temperatures up to 275 F, depending on the corrosive agent carried.

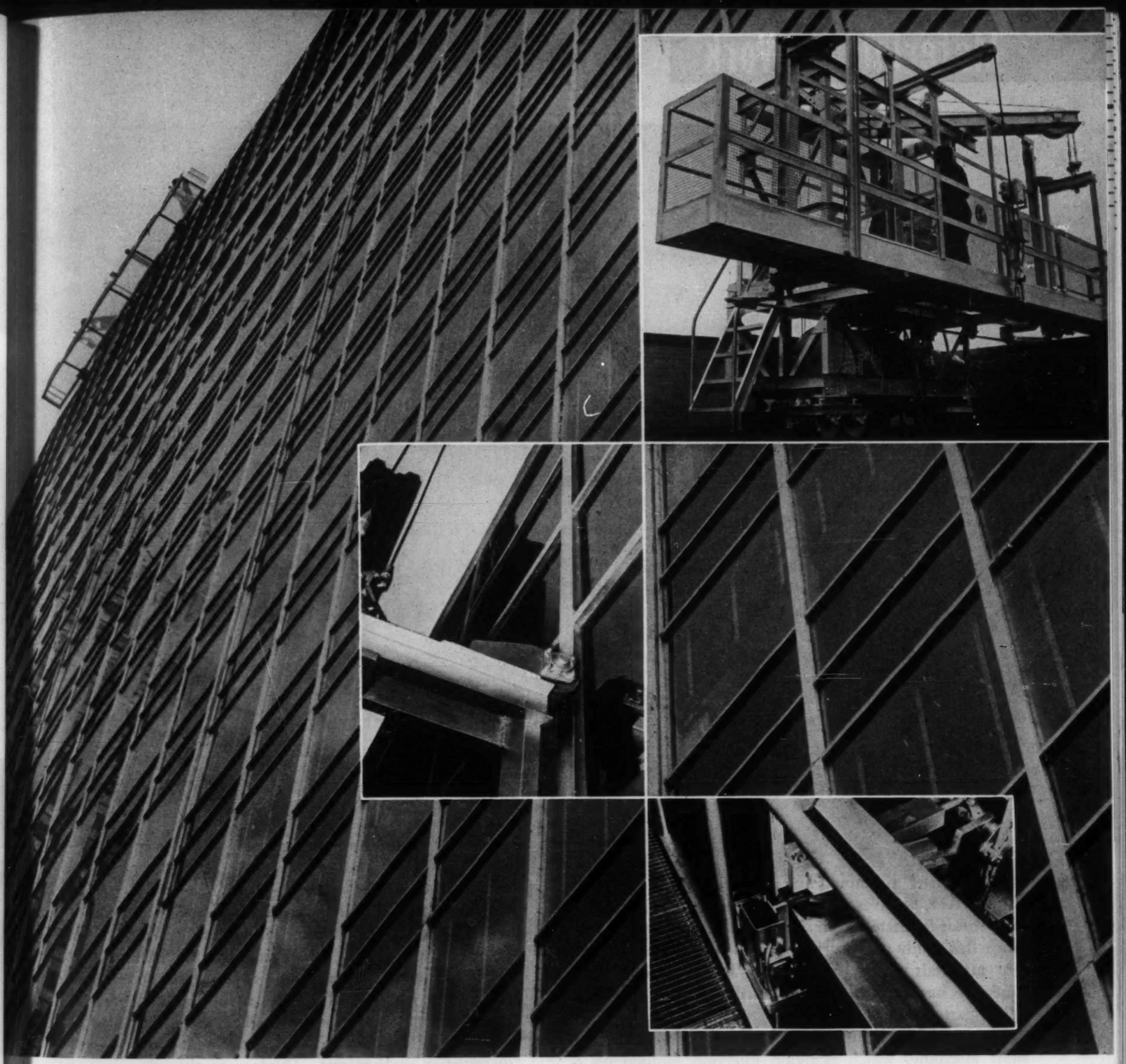






PHENOLIC IGNITION PARTS The Mallory Electric Corp. uses Durez phenolics on two of its products designed for automotive ignition systems. The Mallory special condenser has extremely high dielectric strength, with pressure connections instead of soldered contacts. The phenolic was selected for the condenser because of its high dielectric strength. The Mallory distributor can be supplied for practically all truck and passenger car engines. The cap for the distributor is molded in two parts by the Great Lakes Plastics Co., the same molder that makes the plastic part for the condenser. In the cap, metal inserts and all blind and through holes are molded in one step.

RUBBER-PHENOLIC BUS BAR INSULATION A copper bus bar weighing 14 oz is being encased in a 1/8-in. thickness of molded G-E rubber-phenolic compound, manufactured by General Electric's Chemical Div., for insulation in the handling of household currents. Three sizes are being molded for Murray Manufacturing Corp. by Plastics Molding Corp. Transfer molded, the compound molds with good knitting action, adhering tenaciously to the copper insert. Because of the high resilience of rubber-phenolics, there is no cracking of the molded part despite the differences in coefficient of expansion of the two materials. The weight ratio of metal to plastics is approximately 2:1. The resiliency and high impact resistance of rubber-phenolics are also being used to advantage in other insert applications—press fitting and riveting. The strength of rubber-phenolics is five to seven times that of conventional phenolics.



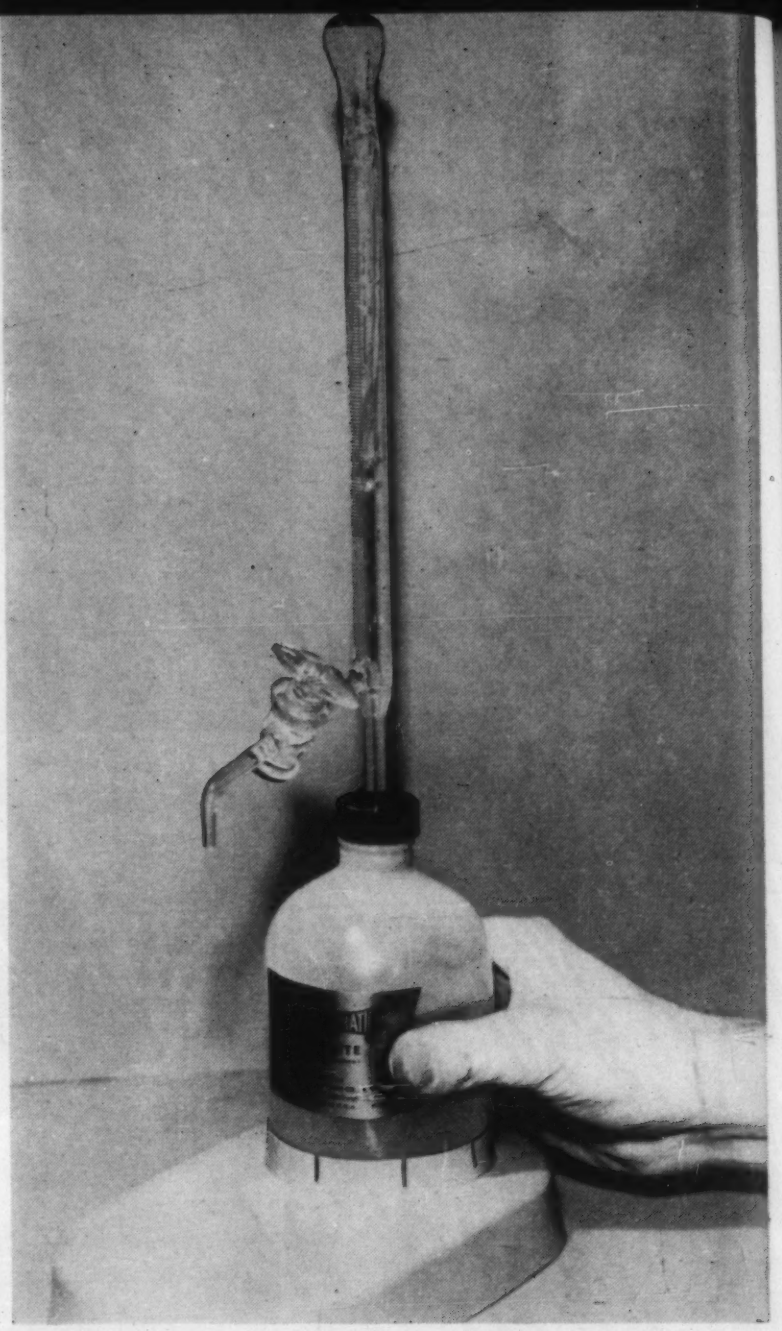
WASHING ELEVATOR FOR STAINLESS STEEL AND GLASS BUILDING Lever House, Lever Brother's recently completed Manhattan skyscraper, is equipped with a window washing gondola which travels around and up and down the face of the building's 1404 windows, spandrels, and stainless steel covered mullions and sills. Manufactured by Otis Elevator Co., this outdoor elevator platform rides on stainless steel guide rails attached to every sixth mullion on the building's exterior.

The gondola is raised and lowered by a traveling crane device that rides on specially designed railroad tracks on the building's roof. When the hoist is above the area to be washed, a plunger is dropped into an indexing socket near the track. This socket is directly in line with one of the stainless steel guide rails on the outside of the building. At the same time, reference pads on either side of the traveling crane bear against the stainless steel coping on the building parapet. This coping provides an accurate, sturdy reference surface for the framework, and keeps the platform exactly flush with the face of the building.

Once the traveling crane is in position, it is impossible for it to move laterally. The window washing gondola, however, can then move vertically. Guide shoes on the gondola slip over the chosen stainless steel guide rail and the platform is lowered over the side of the 306-ft building. To steady the platform, two Micarta covered wheels on either side of the gondola roll down the surface of the building along stainless steel covered mullions. The guide rails themselves are welded structural stainless T sections one story in length, placed end to end down the face of the building with expansion joints between.

To preclude any possibility of binding the elevator platform as it moves up and down the building, each guide rail section is held to a $1\frac{1}{8}$-in. tolerance on straightness and plumb throughout its entire length.

Materials at Work

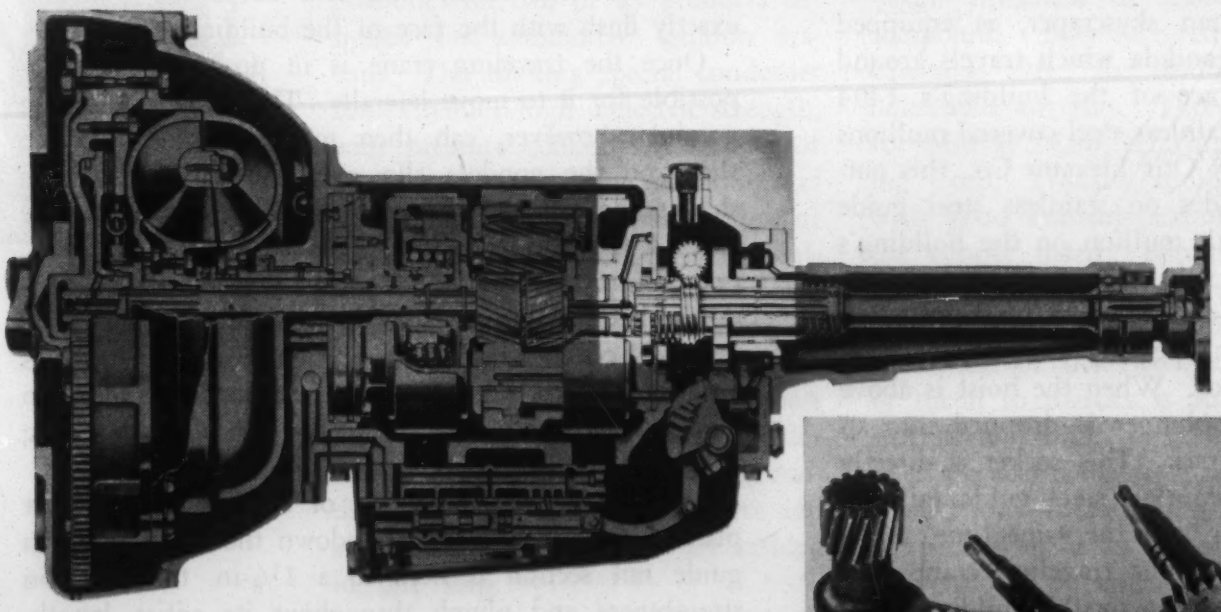


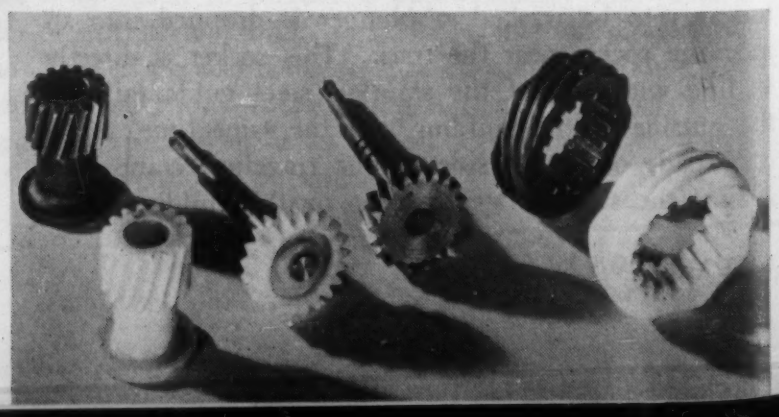
POLYETHYLENE BURETTE BOTTLE A burette unit featuring a polyethylene reservoir which is squeezed to fill an automatic self-leveling burette is being made by the Hagan Corp. The Squeez-O-Matic requires only one hand, whereas older automatic burette assemblies occupied both hands—one for closing a tube orifice, the other for squeezing an aspirator bulb. Use of a polyethylene reservoir not only makes operation of the burette unit easier and simpler, but also provides a container which is highly resistant to chemical attack and will not contaminate standard titrating solutions.

Another feature of the unit is the special base, which holds the plastic bottle and also provides a convenient and stable platform for beaker, flask or dish. The base, also made of special plastic material, is extremely resistant to either mechanical damage or chemical attack. A molded stopper arrangement for the plastic bottle is designed to hold the burette in position and provide a seal between bottle top and burette.

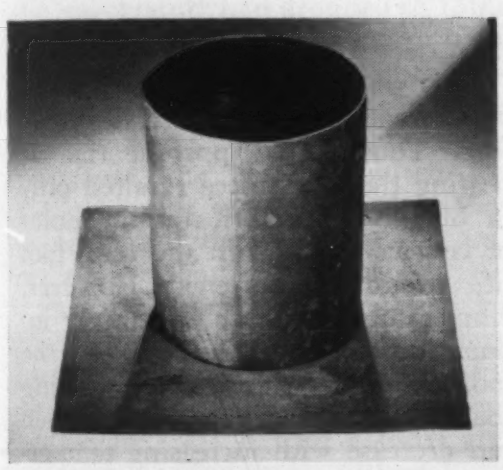
NYLON SPEEDOMETER GEARS Advancements in the nylon industry prompted the Packard Motor Car Co., late in 1949, to investigate the possibility of substituting this versatile material in its speedometer mechanism. Since this study was started, brass—one of the significant materials nylon is replacing—has become critical. Research has now been completed on three essential nylon parts found at the rear of the Packard transmission case: (1) the transmission speedometer pinion and shaft assembly, which is nylon injection molded on a steel shaft, already in production; (2) the transmission 8-tooth speedometer driving gear, which is mounted on the output shaft splines; and (3) the transmission governor pinion.

The two latter parts have been tested, approved and are ready for production. These test gears have been subjected to 100,000 actual miles at the Packard Proving Grounds. Careful tests prove them more durable than their counterparts. The nylon both reduces the cost and improves the quality. The reduction in weight is particularly significant due to the reduction of inertia in sensitive mechanisms. (Nylon, in this case, is 0.146 the weight of steel and 0.132 the weight of brass.)

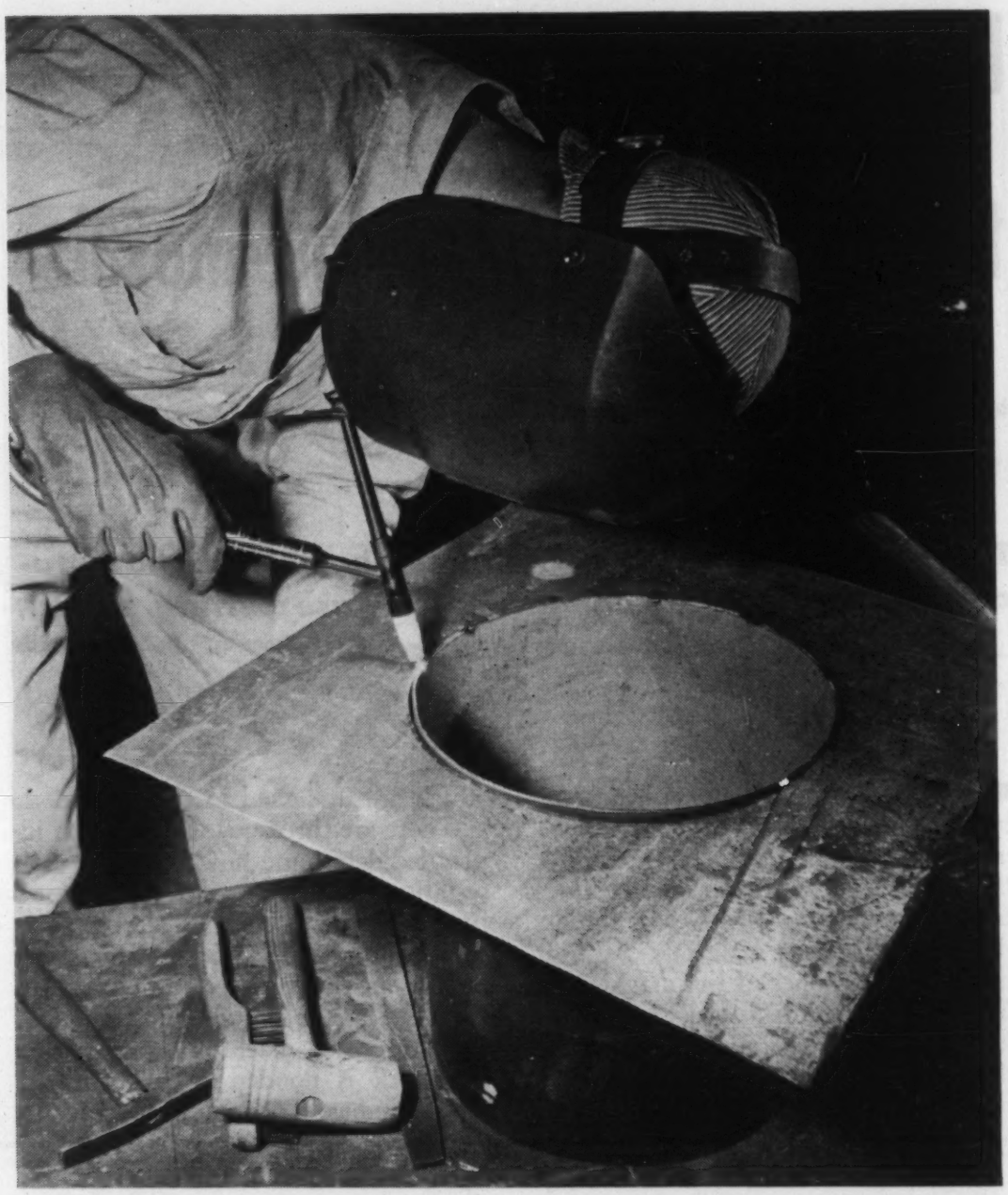




Before welding together components of lead flashing assembly.



After welding. Filler rod is used to fill irregular gaps in the longitudinal joint.



Heliarc welding completes the job in a fraction of the time required for soldering.

Lead Welded by Inert-Gas-Shielded Arc Process

● INERT-GAS-SHIELDED arc welding has been found quite suitable for joining lead. A typical application is the fabricating of lead flashing units. Here the inert-gas process has proved to be a most economical method.

The lead flashing units consist of a vertical cylindrical riser attached to a horizontal flat roof plate. With proper adjustment of welding speed and current, the components are quickly and easily fused together with a Heliarc torch. Filler rod is not needed for the weld that joins the riser to the roof plate. On the longitudinal seam of the formed riser, however, filler rod is added to compensate for irregular joint fitup.

Two features make the inert-gas-shielded arc process readily adaptable for welding lead. One is high welding speed, and the other is low welding current. If slow speeds and high currents are used, concentrated heat causes the molten lead to "run" out of control. With Heliarc welding, however, a speed of approximately 30 in. per min is used with the welding current adjusted to about 50 amp.

The largest saving realized with inert-gas-shielded arc welding of the lead flashing units is in production time. Yet, the quality of the welds is such that the percentage of rejected units is now much lower than it was with the soldered units formerly produced. The smooth, regular welds do not require cleaning or other extensive post-treatment. This is because Heliarc welding employs an inert gas, usually argon, that shields the molten metal from the atmosphere and, therefore, no flux is used.

Due to low welding current requirements and the high welding speeds used in joining lead, fuming is reduced. However, since lead fumes are toxic, the shop is well ventilated and respirators, approved for this purpose by the United States Bureau of Mines, are always used in confined areas.

Hot Machining Methods for Difficult-to-Machine Metals

by A. A. CAMINADA, Purdue University

This survey of latest techniques shows that hot machining can reduce tool wear, increase cutting speed, and improve surface finish.

● INTEREST IN THE possibilities of hot machining has been greatly stimulated during the last few years by the need for methods to machine high temperature alloys and other difficult-to-machine materials. Several different techniques of hot machining have been developed and are in use now, at least experimentally. Each of the methods has certain distinct features, advantages and disadvantages which are discussed in this article.

There are three quantities which in practice determine how readily a material can be machined. They are tool life, tool forces with related power consumption and surface finish. These factors are interrelated and must be balanced for optimum conditions.

In the usual machining procedure, the work is flooded with a cutting oil to reduce friction and cool the tool. However, the work is also cooled, with the result that the shear strength of the material remains high and the chip is more difficult to deform. In the normal method of flooding the work, it is questionable whether the lubricant actually touches the point of contact of the tool and the work, thus decreasing the friction. Although a modified process has been developed to lubricate the work at the point of contact, it is probable that the major result achieved with a cutting fluid is cooling the tool. Hot machining is based on the concept that it would probably be more advantageous to heat the work-piece, thus reducing the shear strength and improving the deformability of the chip than to cool the work to protect the tool. Such a procedure should reduce the power required for machining. Experimental work has indicated that this is the case.

It is well-known that tool life decreases with increasing tool temperature. Thus, it is apparent that if heating the work-piece resulted only in higher temperatures at the point of contact of the chip and tool, tool life would be shortened. However, temperature is simply one factor influencing tool life. The ability of the tool material to abrade the cutting tool is also a factor and one which can decrease with increasing temperature. Raising the temperature of the work-piece can result either in increasing or decreasing tool life, depending on the relationship between these opposing effects.

Hot Versus Cold Machining

HOT-MACHINING	
Advantages	**Disadvantages**
Specially suitable for the machining of hard alloys. The only method which can be used in certain cases. Hot-machined surfaces are noticeably superior. Provides increased tool-file. High rate of metal removal.	Equipment required is expensive. To retain small tolerances, special care and additional equipment are required. The continuous chip requires special device for removal. Difficult set up. The presence of heat creates manipulative difficulties. At present, the developed techniques are experimental.
COLD-MACHINING	
Advantages	**Disadvantages**
Less expensive equipment is required. Small tolerances more easily obtained. No difficult problems with chip removal. Relatively easy setup. Production techniques are very satisfactory. Preferable method with common metals.	Hard alloys are either unmachinable or machined with great difficulty. When these metals are cold-machined, tool-life and rate of metal removal are small. The cold-machined surfaces of such metals shows transverse tears and are non-uniform.

Hot Machining Methods

Although many different methods have been employed in investigating hot machining, there are two basic procedures. In one, the entire piece is heated. In the other, known as hot-spot machining, only the spot immediately in front of the tool is heated and this area is removed as rapidly as possible. These two basic procedures have been applied chiefly in the following ways:

1. Machining the work while it is still hot from other manufacturing processes.

2. Preheating the work and machining before it cools, meanwhile insulating the holding device to prevent excessive loss of heat.

3. Heating the work-piece on the machine immediately ahead of the tool by induction, with a flame, or with an electric arc.

4. Surface heating the work-piece

in advance of the tool.

The first procedure is used in steel mills, for example, for the hot sawing of steel billets. The others have been investigated for the machining of parts in the shop.

Heating the entire piece has been employed in Germany to investigate the machining of steel. Billets were heated to 1830 F and planed with carbide tools. As a result of this experimental work, it was reported that Krupp was building a special machine to be used for the hot planing of billets and plates on a production basis.

The experimental milling of die blocks was investigated by the Kearny and Trecker Corp. For this investigation, the blocks were preheated to 1800 F and mounted in a milling machine. Milling was started when the temperature had dropped to 1500 F, and no attempt was made to hold the material at this temperature during the cutting operation. In spite of this rather uncontrolled testing procedure, the power required for hot machining was one-third of that necessary for the corresponding operation at room temperature.

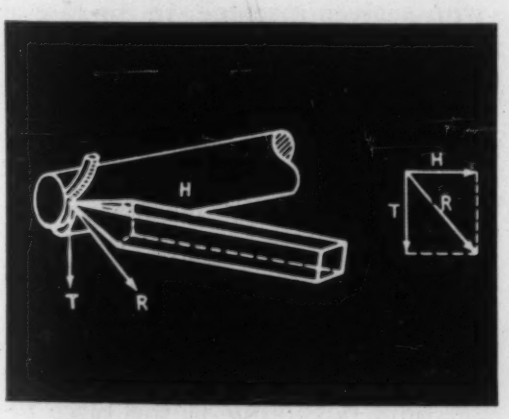
Surface heating was employed by White and Aust for machining swaged tungsten bars intended for stress-rupture tests. The bars were heated to 1300 F with a torch and cut with a carbide tool. Although the tool required regrinding after cutting three bars, the results were considered to be good.

Goddard and Goddard used a surface heating procedure to investigate the hot-milling of SAE 4340 steel plate. A carbide cutter was used and the temperature of the work at the point of contact with the tool was 1100 F. The power required for cutting at this temperature was about two-thirds that required at room temperature.

An investigation in the laboratories of Sam Tour and Co. was undertaken to study the hot spot machining of a number of metals. A comparison was made between flame heating and induction heating. The steel was cut with carbide tools as rapidly as possible after the surface temperature reached 1500 to 1600 F. For a number of types of steel, it was found that the pressure on the tool tip was reduced by hot-spot machining. It was determined also that there was no chatter and no tool breakage and the shank of the tool remained cool during the machining tests. As an example of the results obtained, the NACA recommenda-

Comparison of Heating Methods

ADVANTAGES		
Flame-Heating	**Induction-Heating**	**Arc-Heating**
Relatively inexpensive. Can be easily controlled, permitting long machining operations. It is possible to obtain the high power density required in some operations.	Cleanliness and convenience, simple and easy to operate. Fast heating. Permits concentration of heat in the reduced area of the work.	Clean but less convenient and more difficult to operate than induction heating. Fast heating. Permits concentration of the heat in the reduced area of the work.
DISADVANTAGES		
Flame-Heating	**Induction-Heating**	**Arc-Heating**
Flame splash. Intensity of light from the flame. Excessive heating of tool and machine. Heating relatively slow. It is difficult to concentrate the heat.	Difficult to design the coils. Expensive to install. Sometimes does not give the required power density. It is difficult to use the same piece of equipment with materials of different electric and magnetic characteristics.	Difficult to design. Relatively expensive.



The unit pressure P_c is the most important factor in tool failure and is directly related to the machining temperature. The relationship of P_c to the energy consumed in shear, friction and chip deformation and to the area of the chip is indicated by the following equations. (Tour, Tool Engineering)

$A = f \times d$ where T = tangential load on tool

$R = \sqrt{T^2 H^2}$ H = horizontal load on tool

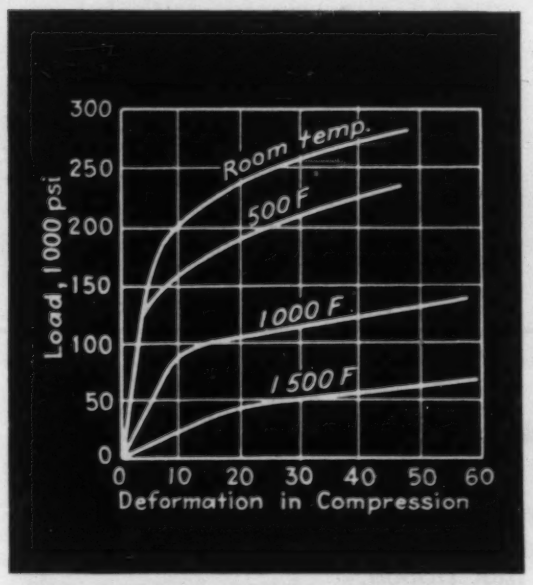
$P_c = \frac{R}{A}$ R = resultant load on tool

f = feed per revolution

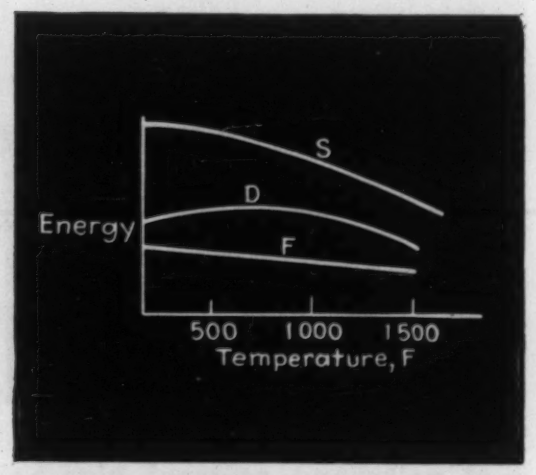
A = area of chip

d = depth of cut

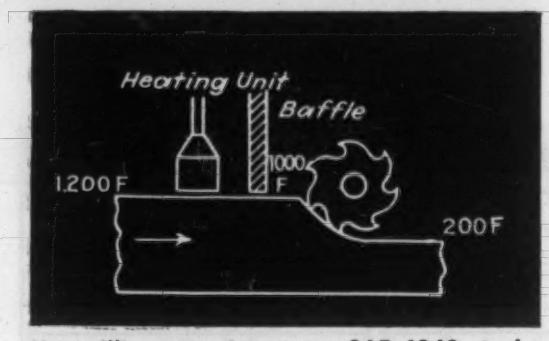
P_c = unit pressure



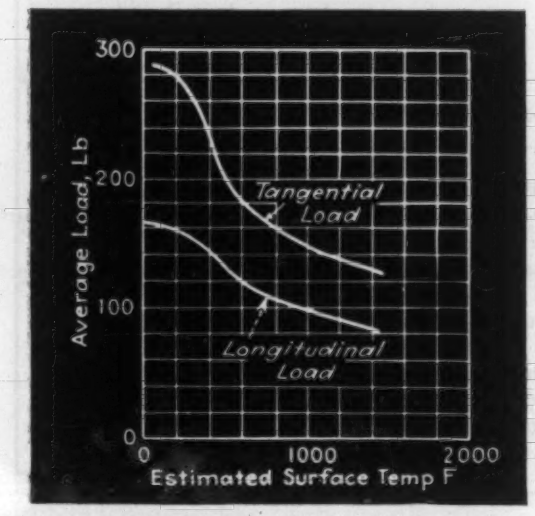
Decrease in load caused by deformation of the chip when steel is heated. The shear strength and the resistance to deformation of steel decrease with rising temperature. Friction is reduced also. The result is a decrease in unit pressure with rising temperature. (Tour, Tool Engineering)



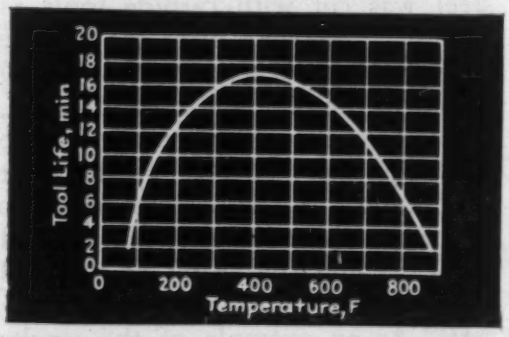
Effect of temperature on the energy absorbed in chip formation. Curve S represents energy absorbed in starting or forming chip; curve D, that absorbed in the deformation of chip; curve F, energy absorbed because friction of chip is sliding across the tool face. (Tour, Tool Engineering)



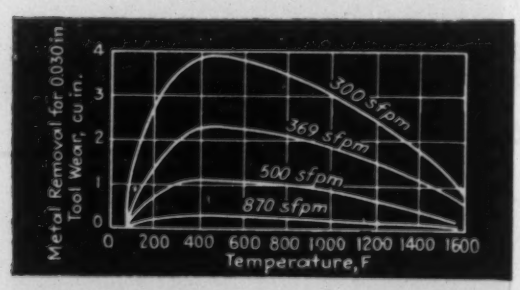
Hot milling experiments on SAE 4340 steel showed a reduction of 33% in power required at 1100 F below room temperature requirements. (Hubbard, Steel)



Relationship between surface temperature of work and tangential and longitudinal loads on a medium carbon steel (Navy-Grade M). Testing conditions: 73 rpm, 0.010-in. feed, 0.0625-in. depth of feed, 54 sfpm. (Tour, Tool Engineering)

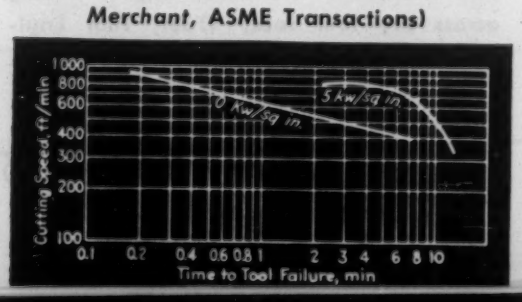


Effect of temperature on tool life in cutting Type 304 stainless steel. Conditions: general purpose carbide tool, 500 sfpm, 0.080-in. depth of cut, 0.011-in. per revolution feed. (Armstrong and Cosler, Materials & Methods)


Metal Removal for 0.030 in Tool Wear, cu in.
300 sfpm
369 sfpm
500 sfpm
870 sfpm
0 200 400 600 800 1000 1200 1400 1600
Temperature, F

Relationship between tool life and cutting speed for stainless steel cold machined and hot machined at 5.0 kw/sq in. constant heating. (Armstrong and Cosler, Materials & Methods)

Effect of temperature on metal removal for Timkin alloy 16-25-6. (Krabacher and Merchant, ASME Transactions)



tions for optimum results in the machining of S-816 steel call for rates of approximately 2.3 cu in. of metal removal per hr. At 1500 F it was possible to increase the rate to approximately 270 cu in, per hr with no apparent tool wear, excellent finish and reduced tool loading and power requirements.

Armstrong and Cosler employed an arc method for heating the work, the arc being struck between the material to be cut and a carbon electrode. A comparison of room temperature with elevated temperature cutting at various speeds is shown in an accompanying graph.

Krabacher and Merchant investigated tool life and the mechanics of cutting using lathe and milling operations. Carbide tools were used. They concluded that the major factor producing lower tool forces and less power consumption at elevated temperatures was the lower shear strength of the material. As a result of their tool life tests, they concluded that there is an optimum temperature range at which, for given machining conditions, the tool life will be a maximum. Their results indicated that heating improved the machinability of certain high temperature alloys but did not improve that of readily machinable steels.

Quality and Tolerances

As far as the quality of finish of the work is concerned, there is a marked improvement with hot machining. When a really heavy cut is taken cold, the under side of the chip appears quite smooth but the surface of the work, from which the chip was removed, is covered with many crevices. This does not occur with hot-spot machining. Tool marks are formed but they travel around the periphery; in cold cutting they are transverse. These are tear lines in the surface caused by the tearing of the chip. Such lines do not develop when the material is hot because the steel in this case does not have a tendency toward cold fracture. In general, the chip is a continuous hot ribbon.

Tolerances seem to be inferior to those established for cold machining for readily machinable materials, because of expansion of the workpiece. In one investigation, it was determined that 54% of the total heat input is contained in the surface layer which is to be removed during the machining operation; the remainder either diffuses into the work or is removed immediately after the cut by the stream of coolant. In the case of a 4-in. dia bar of steel the average temperature would be raised 85 F if the heat diffused were not removed. As a result, the bar would expand 0.002 in., which is not excessive for roughing cut, but cooling would be desirable for finishing cuts. It should be recalled, however, that with some materials there is no choice between cold and hot machining, for the materials cannot be cut cold satisfactorily.

Economic Aspects

Since the work done on hot machining has been experimental, it is not possible to make a direct comparison of the costs of hot and cold machining. However, certain indications have been obtained.

Calculations of the total power requirements for hot and cold machining of stainless steel showed that, for hot machining the sum of the power required for the machine tool and for heating was about the same as that required in cold machining for the machine tool alone. The economic advantage of hot-machining must, therefore, be based on other considerations. One is the amount of work which can be done with a given machine. In the case of stainless steel, the cutting force in hot machining is reduced to one-third of that required in cold machining, indicating that the capacity of the machine tool would be tripled.

With less readily machinable materials, the hot machining process has a definite advantage, since the alternative is a more expensive finishing method. With vitallium, for example, hot machining seems to be the only possibility if the piece requires machining.

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Stainless steels lend themselves well to cold forming. Here Type 304 is drawn into a small part through a total reduction from blank area diameter of 80%. (Allegheny Ludlum Steel Co.)

Cold Forming Stainless Steel Parts

by Kenneth Rose, Western Editor, Materials & Methods

MATERIALS & METHODS MANUAL No. 84

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

JULY 1952

Stainless steels can be fabricated by cold forming methods almost as readily as mild steel if a few special considerations are kept in mind. However, the various stainless steel grades vary considerably in their formability characteristics, and selection of the proper grade for a particular cold forming operation is a matter for careful study. To aid the engineer in selecting the proper stainless steel for his job, this Manual discusses the:—

- **Selection Factors**
- **Cold Forming Properties of Stainless Steels**
- **Cold Forming Methods**
- **Tool and Die Materials**
- **Annealing Procedures**

Steady growth in the tonnage of stainless steels used for both consumer goods and for industrial equipment is evidence of the increasing recognition of the merits of these materials. Resistance to deterioration at elevated temperatures, resistance to weathering, resistance to chemical corrosion, good strength and attractive appearance are their outstanding properties. In addition, they are relatively easy to work and relatively low in cost as compared with many of the corrosion resistant high-temperature alloys.

In the earlier days of stainless steel use, there was some hesitancy about adopting them, because they were thought to be difficult to fabricate. However, techniques for working them were soon developed to the point where the stainless steels could be formed almost as readily as mild steel, except for a few special considerations. Since they are tough, strong metals, they require more power to form than mild steel; also, special allowance must be made for springback. Stainless steels are used for their attractive appearance and corrosion resistance, so particular care in handling the metal is an essential part of forming techniques. With the recognition of the special characteristics of stainless steels, they can be formed on standard equipment.

Because stainless steels are a material of inherent beauty, and are not usually finished with a protective or decorative coating, they lend themselves particularly well to cold forming. The original surface of the metal is preserved to a considerable extent in contrast to the results of overall machining or hot forming. The surface finish, however, is usually altered during forming operation, so that polished stock is not used except for parts in which the degree of deformation is small. There are protective coatings that can be applied to protect the finish of the material during moderate cold forming.

Selection Factors

All stainless steels can be fabricated by cold forming methods, though they differ considerably in the readiness with which they can be so formed. Selection of the proper stainless steel for a cold forming operation is a matter for careful study. Some of the considerations are:

1. Nature of service required. The degree of corrosion resistance needed is influenced by such factors as frequency of cleaning; type, temperature and concentration of the corroding agent; location of the piece in the assembly, if any. Type and degree of stress to be resisted is also important.

2. Other operations to be performed. If machining or welding is to be used either prior to or following the forming of the piece, selection of the material must be made with such requirement in mind.

3. Cost. All stainless steels are costly compared to mild steel, but the price differential between two grades under consideration for a given use may be as much as 10 to 15¢ per lb.

4. Availability. This is subject to change with changes in government restrictions, and occasionally with certain manufacturing considerations. At present, the nickel-bearing grades and columbium-stabilized grades are not generally available for civilian production, but most grades can be obtained for fabricating military items.

Having selected the most satisfactory grade of stainless steel, the prospective user must decide upon:

1. The metallurgical state to be specified. Stainless grades for cold forming are usually preferred in the fully annealed condition.

2. The finish of the sheet or other form. This will depend upon both the final finish desired and the processing to be carried out. For example, for parts to be deep drawn, a dull cold rolled finish would be specified, while for a part to be shallow formed and polished in finished form, a bright cold rolled, or even a standard polished finish would be ordered. The standard mill finishes obtainable on stainless steels are given in the accompanying table.

3. The form, size and gage of the material. These are dependent upon the design and the mechanical processing factors.

Sheets and strip of stainless steel, as a result of the rolling process, have one side in which the quality of the surface is slightly better than the other. This is called the prime side, and the other side is called the reverse side. The identity of the prime side is preserved by the stainless steel producers, and is indicated by placing the inspection stamp, on sheet stock, on the reverse side, or by coiling the material with the prime side out. The prime side polishes somewhat easier than the reverse side, so finishing can be facilitated by planning the handling of the material accordingly.

The cold forming processes used on stainless steels include blanking, shearing and punching; press or brake forming; drawing; perforating; cold heading; spinning; and draw rolling. The term "cold forming" is used broadly to include not only those operations in which the material is worked at room temperature, but those in which the material

Standard Mill Finishes on Stainless Steel Stock

#1—Hot rolled, annealed and pickled. Used mostly for technical applications. Seldom used for work that will be polished, unless the processing and annealing would destroy a higher finish.

#2D—Dull cold rolled. Much smoother than the #1 finish. Excellent for drawing and other cold working because it has maximum ductility and can be polished and buffed after forming.

#2B—Bright cold rolled. As this material is given a light cold rolling as a final step, it is slightly harder than the #2D finish. It does not draw as well, but provides a better surface for polishing operations. Frequently used for pieces to be polished after shallow forming or stamping.

#4—Standard polished on one or both sides, this is the commercial polished sheet. Specified for shallow drawing or forming operations where the mill finish will not be destroyed in processing.

#6—Tampico brushed. This is a satin finish obtained by finishing with a rotating brush charged with fine abrasive. It has low reflectivity, and is specified for architectural work and for pieces in which the satin finish is desired as a contrast with higher polished surfaces.

#7—High luster polish. This is a semimirror finish, useful where the stock will be used as received for decorative work, trim, dairy machinery, etc.

Strip stainless steel is supplied in the #1 and #2 rolled finishes, and in the #4, #6 and #7 polished finishes. Heavy plate is not polished as a stock finish, but is nearly always supplied in the #1 finish. Cold heading wire is supplied in coils with a soap or copper coating.

or the dies, or both, are warmed to temperatures as high as 300 F, a procedure that reduces the tendency of the stainless steels to work-harden and also lowers the initial stiffness of the steel. Wire drawing, a specialized process, is not included in this Manual. The forming operations will be described primarily with regard to the type of stainless steel most suitable for fabrication by that method, rather than with regard to the manufacturing processes themselves.

In addition to the solid stainless steels used for cold forming, there are composite materials in the market that meet needs both of economy and of special utility. Stainless steel can be obtained as a cladding over one or both sides of mild steel, substantially reducing the cost of the material when it is used as plate or other formed material for such purposes as chemical equipment. Claddings are used for added utility, and without any cost cutting intention, in cookware, where a metal having a higher thermal conductivity will reduce the tendency to local overheating and uneven heating that results from the poor thermal conductivity of most of the stainless steels. For this purpose the added metals are usually aluminum or copper. Double-clad carbon steel is being used for domestic cookware also.

Cold cupping a stainless steel blank in one operation after blank has been cut from sheet stock and punched. (Armco Steel Corp.)

Cold Forming Properties of Stainless Steels

A discussion of the most important of the standard types of stainless steels from the standpoint of their cold forming qualities follows and should give a clear idea of the extent to which specific types can be used for cold forming.

Type 301—With good workability, good corrosion resistance and good mechanical properties, Type 301 stainless is widely used for structural parts in railway cars, buses, trains and planes. It is used more for brake-formed or shallow-drawn pieces than for deep drawn parts. In the fully annealed state it has an elongation of about 50%, with a tensile strength of about 90,000 psi and a yield strength of about 40,000 psi, which indicates good drawability. Strength properties in the fully work hardened condition are: tensile strength, 185,000 psi; yield strength, 140,000 psi; elongation in 2 in., 8%. Strength for partial work hardening will lie between these sets of values.

If the drawn part must be welded, spot welding should be used wherever possible, as the localized heating will not reduce the strength of the work-hardened part appreciably. Arc or gas welding cause considerable loss of strength .

Type 302—The excellent drawability of this 18:8 grade makes it the first choice for parts requiring a severe draw, and especially if the work must withstand severe corrosive conditions. It is the most widely used of all the austenitic stainless steels, going into chemical and food equipment, domestic utensils, architectural and decorative uses, jewelry, etc. Strength properties in the fully annealed condition are: tensile strength, 85,000 psi; yield strength, 35,000 psi; elongation in 2 in., 50%. Work hardening will increase strength somewhat. Type 302 is readily welded by most commercial methods except fire welding, and the welds are ductile without annealing. Carbide precipitation may occur if it is heated in the 800 to 1500 F range, but the carbides can be put back into solution by heating to 1950 F and cooling rapidly. Type 302 is more ductile than mild steel in deep drawing, but requires

considerably more power because of its higher strength. Under favorable conditions this material has been drawn to 50 and 55% reduction in one operation. After severe working it should be annealed at once, however, or it may crack within a few hours.

A variation of Type 302, designated as 302B, contains additional silicon to provide scaling resistance at elevated temperatures. Type 303 is a free machining grade of the 18:8 composition.

Type 304 is a low-carbon 18:8 intended for use where welds must be made but re-solution of carbides may not be feasible. Drawing is not a common fabricating method for these types, and it should be used with care if at all, as there is a tendency for them to split.

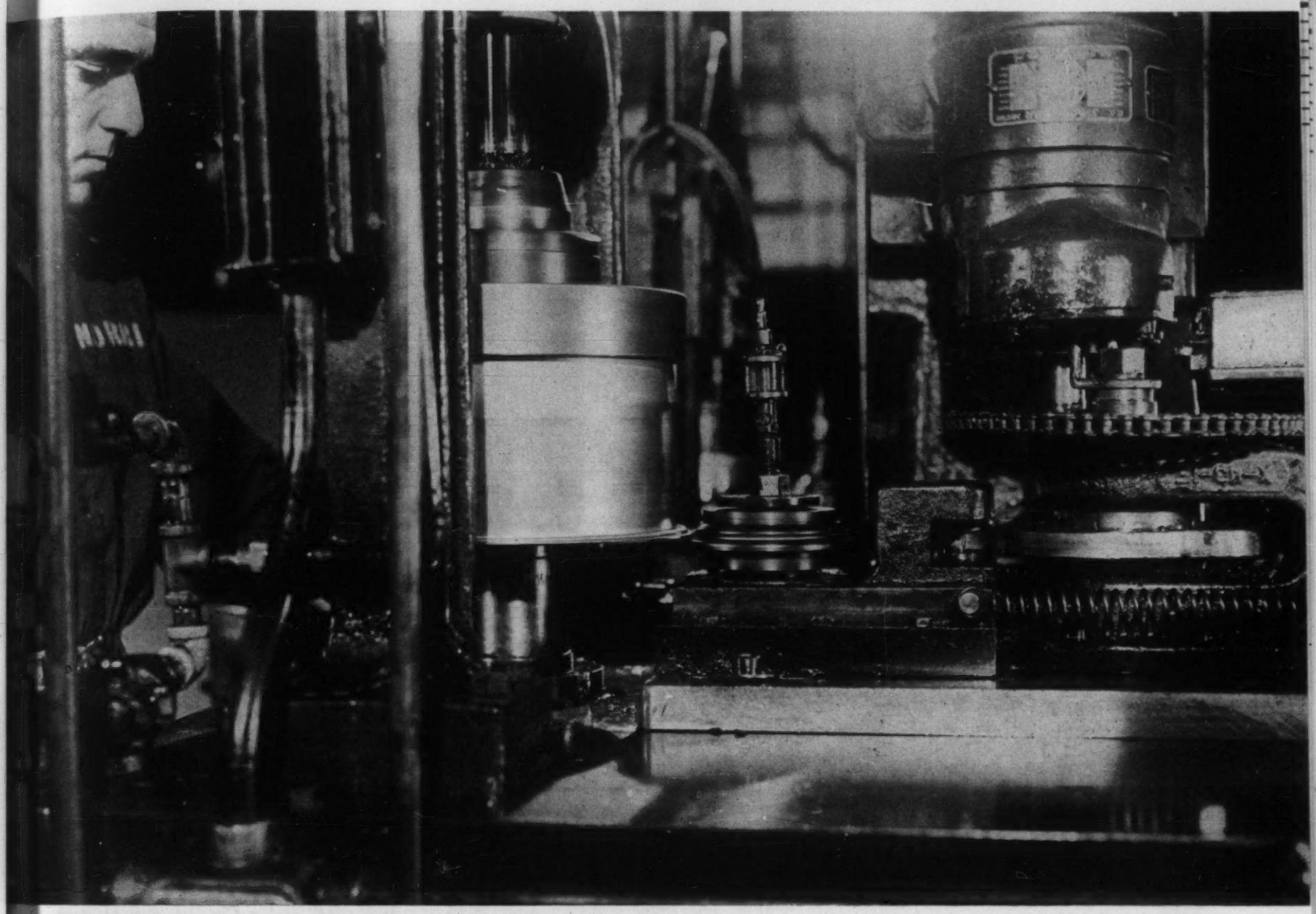
Type 305—This free-spinning grade, in which nickel content is increased about 2%, is a special analysis of the basic 18:8 composition intended for difficult forming operations. It can be annealed to a lower hardness than Type 302, does not work-harden as rapidly, and cannot be work-hardened to as high a hardness. It is somewhat more expensive than the standard 302 grade, but economies in processing will offset the higher cost. It can withstand two or more draws, if not too severe, without an intermediate anneal, and the saving in annealing and the resulting cleaning will equalize costs with other grades. It also anneals at a lower temperature than Type 302—in the range 1750 to 1950 F. In the fully annealed condition, Type 305 has the following strength properties: tensile strength, 85,000 psi; yield strength, 38,000 psi; elongation in 2 in., 50%. Hardness in the fully annealed state is about 80 Rb. Type 305 stainless steel is used for deep drawn utensils, drawn tank bottoms, etc.

Type 308—This modification of Type 304 has slightly higher alloy content to give it better resistance to corrosion and heat, and its principal uses are for welding rods and fur-

The good cold forming properties of annealed stainless steels make possible deep forming of many cylindrical shapes.

Cold Formability and General Properties of Stainless Steels

Type and Grade		General Composition	Hardening Properties	Cold Working	Corrosion Resistance	Weldability	Use
Chromium Types, 400 Series	Martensitic	12–18 chromium, 0.10–1.20% carbon	Heat-hardenable	Fair cold formability	Corrosion resistance inferior to that of ferritic or austenitic types	Weldable, but requires an anneal	For mildly corrosive conditions
Chromium Types, 400 Series	Ferritic	15–27 chromium, about 0.12% carbon max.	Not heat-hardenable, but work hardens	Good cold formability	Good corrosion resistance	Weldable, but welds tend to be brittle even after anneal	For elevated temperature use, automotive trim, resistance to nitric acid
Chromium-Nickel Types, 300 Series	Austenitic	16–30 chromium, 6–26 nickel, about 0.25% carbon max.	Not heat-hardenable, but work hardens	Best cold formability	Best corrosion resistance	Weldable, but unstabilized grades may show carbide precipitation	For severely corrosive conditions, elevated temperature service



The austenitic type stainless steels are widely used for spun parts. Here the edge of a sauce pan is being spun down at Norris Manufacturing Co. (U. S. Steel Co.)

nace equipment. It can be drawn like the average austenitic stainless steel. Strength properties of the annealed alloy are: tensile strength, 85,000 psi; yield strength, 30,000 psi; elongation in 2 in., 55%.

Type 309—This is another high-temperature material, possessing high creep strength as its special property. Its high alloy content gives it good resistance to scaling or oxidation at temperatures to about 1900 F, but it may be attacked by high-sulfur atmospheres. Welds are ductile and require no heat treatment. It can be deep drawn and otherwise cold formed about as readily as other austenitic alloys. Strength properties in the annealed condition are: tensile strength, 95,000 psi; yield strength, 40,000 psi; elongation in 2 in., 45%. It is used for heat treat furnace equipment, oil refining equipment, chemical equipment, oil burner parts, conveyor parts, etc.

Type 310—This grade can be deep drawn without difficulty. A high-temperature grade that retains good strength and toughness and scaling resistance to about 2000 F, Type 310 is used in gas turbine parts, furnace parts, heat treat equipment, oil refinery equipment, etc. It is the preferred grade where reducing or carburizing atmosphere are encountered at high temperatures, and has somewhat higher creep strength and mechanical properties under heat than Type 309. It is also much used for welding electrodes for low chromium alloys. Strength properties for the fully annealed steel are: tensile strength, 95,000 psi; yield strength, 45,000 psi; elongation in 2 in., 50%. Welds are ductile without annealing.

Type 316—Addition of 2 to 3% of molybdenum and a few percent of nickel to the standard 18:8 composition produces this type. It can be deep drawn without unusual difficulty. Type 316 has unusually high chemical resistance, and is especially effective against acid agents, such as sulfite liquors in wood pulping. Where brines, sulfur-bearing liquors or halogen salts are the corrodants, Type 316 will resist pitting better than the other austenitic alloys. In addition to its use for pulp and papermaking equipment, type 316 goes into other chemical and pharmaceutical equipment, food processing machinery and the like. It is available in two variations of the standard composition, intended to provide better corrosion resistance if heated or if welding is a part of the fabricating. Carbide stabilization can be accomplished by addition of columbium in one of these variations, or carbide precipitation can be eliminated by holding carbon to a 0.03% maximum in the other. Typical strength properties for the annealed material are: tensile strength, 90,000 psi; yield strength, 40,000 psi; elongation in 2 in., 50%. The metal also possesses good creep strength at elevated temperatures.

Type 317—This steel can be

A series of cold forming operations are required to produce stainless steel milk cans at International Harvester Co. They include blanking, deep drawing and trimming.

thought of as a Type 316 in which the alloy content has been increased to give it additional chemical resistence. It is used largely in equipment for the chemical and pharmaceutical industries. Strength properties are about the same as those of the 316 material, and it can be deep drawn about as readily.

Type 321—This is a 304 stainless steel with titanium added to stabilize the carbides, and like 304 steel, it is intended for service under mildly corrosive conditions when welding or holding at high temperature might cause some carbide precipitation. Because it has satisfactory strength properties at elevated temperatures when the corrosive conditions are not severe, it finds use for airplane exhaust stacks and collector rings. It gives good service in the 1000 to 1600 F range. Type 321 can be deep drawn as readily as most of the austenitic stainless steels. Strength properties in the annealed condition are: tensile strength, 90,000 psi; yield strength, 35,000 psi; elongation in 2 in., 50%.

Type 347—When stainless steel of the 18:8 type is required to withstand severe corrosive conditions in the 800 to 1500 F range, the addition of a stabilizer to the composition will prevent the precipitation of carbides at the grain boundaries in the metal, and consequent corrosion. Columbium is added to the 18:8 formulation as a stabilizer. Creep strength is high up to the 1200 to 1300 F, and the material is used in jet engine parts, aircraft exhaust stacks, collector rings, and chemical equipment. Type 347 draws well. Typical values for strength of the metal in the annealed state are: tensile strength, 90,000 psi; yield strength 40,000 psi; elongation in 2 in., 45%.

Type 403—This martensitic stainless steel was developed originally for turbines, but it is now used for many applications in which good mechanical strength and good resistance to wet erosion at slightly elevated temperatures are requirements. It is now finding use is gas turbines for highly stressed portions of the structure. Maximum strength is developed only by heat treatment.

Strength properties are:

Full Annealed	
Tensile strength	75,000 psi
Yield strength	40,000 psi
Elongation in 2 in.	30%

Heat Treated	
Tensile strength	110,000 psi
Yield strength	85,000 psi
Elongation in 2 in.	20%

While Type 403 is cold formed for many applications, it is not usually deep drawn. The metal should be fully annealed before attempting a draw, and must be re-annealed if several successive draws are attempted. Type 403 stainless steel is fully annealed by heating to 1550 to 1650 F and cooling in the furnace to about

1100 F, then cooling more rapidly. For a process anneal, the metal can be taken to 1250 to 1350 F, permitted to soak, and then furnace cooled. The heat treatment to develop best strength consists of heating to 1700 to 1850 F and quenching in oil. Very thin sections can be quenched in air. It is then drawn back to obtain the desired properties, avoiding the range between 700 and 1100 F, which produces low impact strength.

Type 405—A ferritic stainless steel, Type 405 is essentially the 403 composition with carbon held to a low value and a fractional percentage of aluminum added to permit welding without annealing. Strength is about the same as in the basic composition. Its use is in welded assemblies that are not exposed to temperatures above about 1200 F in service, and cannot be annealed after welding.

Type 410—This is the basic type of the 12% chromium stainless steels, and is the most widely used of the hardenable grades. It is martensitic after heat treatment. In the annealed condition it is capable of severe deformation, and it can then be heat treated to high physical properties. It welds easily, but the weld should be annealed, particularly if the piece will be subjected to shock or to cyclic stresses. The 410 type has good resistance to scaling and good mechanical properties at temperatures up to about 1200 F, and it is frequently used for low temperature furnace parts, steam valves, oil burner parts, etc. Its resistance to atmospheric and chemical corrosion is ample for such uses as cutlery, mining machinery, railroad equipment, gage parts, screws, and the like. Strength properties in the annealed condition are: tensile strength, 70,000 psi; yield strength, 40,000 psi; elongation in 2 in., 30%.

Type 414—This grade is a 410 type with about 2% nickel added to improve corrosion resistance. It is martensitic. Not only is corrosion resistance improved, but mechanical properties are higher also. The 414 grades are not usually deep drawn, but can be shallow formed without difficulty. It is used in hardware, gages, valves, etc. The 414 grades are not usually deep drawn, but can be shallow formed without difficulty. It is used in hardware, gages, valves, etc. Type 414 is somewhat difficult to anneal fully, but a low anneal can be accomplished with satisfactory results. This is done by heating to 1200 to 1300 F, which relieves stresses. It can be air hardened by cooling rapidly from 1700 to 1900 F, preferably using a temperature near the upper part of the range. The hardness is then drawn back by tempering at 400 to 1200 F, but avoiding temperatures between 700 to 1100 F for parts subject to impact.

Strength properties of the annealed material are: tensile strength, 115,000 psi; yield strength, 90,000 psi; elongation in 2 in., 20%.

Type 416—This is a free cutting variation of Type 410, and is intended primarily for machining stock. It has about the same corrosion resistance as the basic type, and is heat treated in the same way. Strength properties are the same also. While this grade would not ordinarily be selected for drawing, it can be drawn moderately well.

Type 420—This high carbon modification of the 12% chromium type is intended for use where higher strength or greater wear resistance is required. It is martensitic, and can be hardened up to about 500 Brinell by heating to 1700 to 1900 F, preferably the higher temperatures, and quenching in oil. While not usually fabricated by deep drawing, it can be shallow formed without difficulty. Type 420 stainless steel can be annealed by heating to 1500 to 1600 F and furnace cooling to about 1100 F. A low anneal or process anneal will be accomplished by heating to 1250 to 1350 F and air cooling. Strength properties in the annealed condition are: tensile strength, 95,000 psi; yield strength, 50,000 psi; elongation in 2 in., 25%.

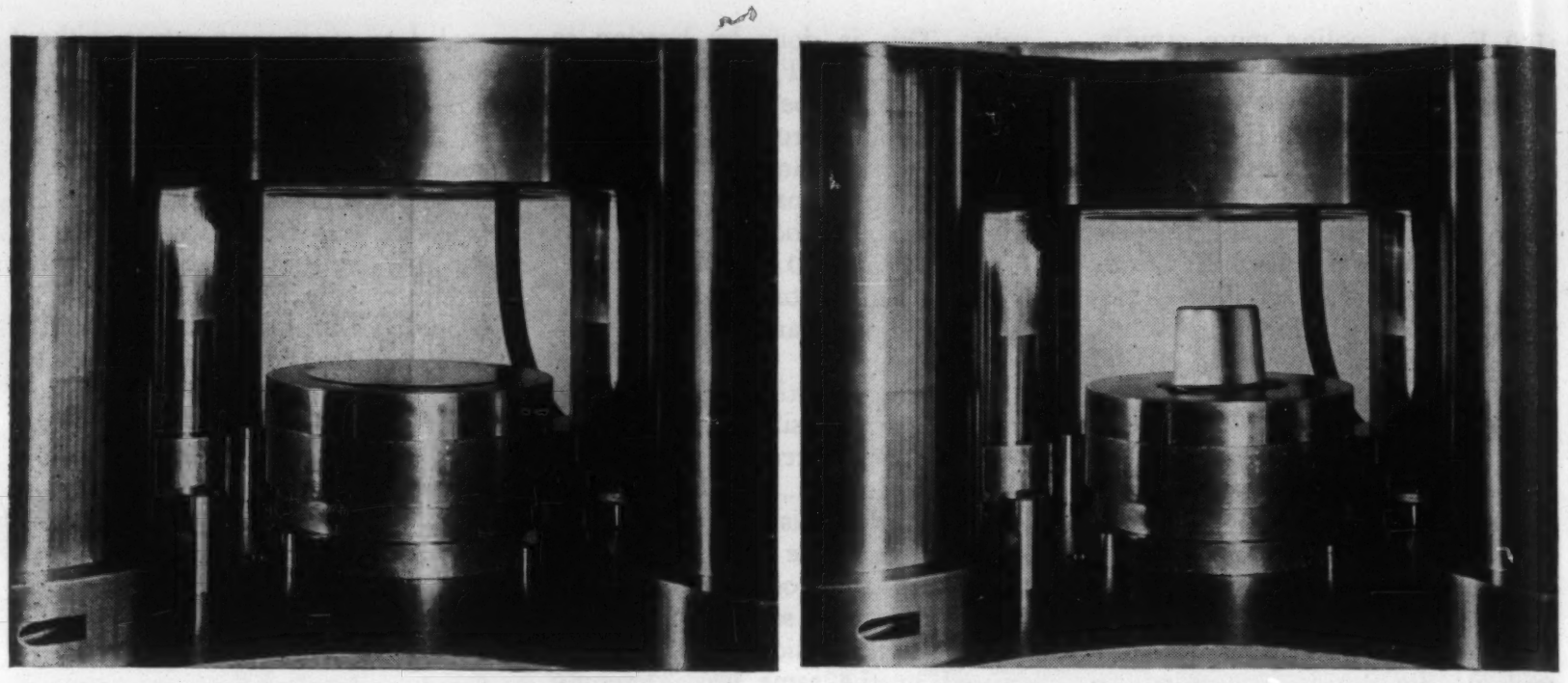
Type 430—This ferritic grade is an important material for deep drawing and for cold forming in general. It has fairly good corrosion resistance, and is much used in architectural hardware and paneling, automotive trim, nitric acid plant equipment, fastenings, oil burner parts, tubing, and chemical machinery. It cannot be hardened by heat treatment. Typical strength properties for the annealed alloy are: tensile strength, 75,000 psi; yield strength 45,000 psi; elongation in 2 in., 30%. Type 430 steel has good corrosion resistance at elevated temperatures, with a top service temperature at about 1400 F. It remains tough in the 700 to 1100 F zone, in which most martensitic grades tend to become brittle, but may itself lose toughness if cooled to room temperature without first taking the heat to the 1400 to 1550 F range. It possesses good resistance to sulfur-bearing gases at all temperatures to 1400 F. Because of its very low coefficient of thermal expansion, it is frequently chosen for elevated temperature service in which intermittent heating and cooling is a condition. Welds tend to be brittle, and annealing does not completely restore ductility. Spot welds may be satisfactory if stresses in service are low, and if shock loading is light.

Type 430 F—A free machining grade of the 430 composition, Type 430 F has the same general properties as the basic composition. Corrosion resistance is a littler lower. This grade is not usually considered for deep drawing.

Type 431—A high strength martensitic stainless steel. Type 431 is used mostly for aircraft stress members that are heat treated to superior tensile, yield and impact strength. It is tougher than Type 430. As it does not have good drawing properties, it is seldom used for this type of forming.

Type 440—This martensitic type is made in three grades, representing a series of carbon contents: A, with 0.60 to 0.75% carbon; B, with 0.75 to 0.95%; and C, with 0.95 to 1.20%. For better machinability, a 440 F composition containing sulfur or selenium is available. They are intended to be heat treatable to highest strength and hardenability of the stainless steels, and are not primarily cold forming materials. Even in the annealed condition, Type 440 is not intended for deep drawing.

Type 446—The ferritic stainless steel standardized as Type 446 is intended for service at elevated temperatures under light load. It has good resistance to oxidation and scaling at elevated temperatures, and to sulfur-bearing gases also, but loses strength at temperatures above 900 F. As it has the lowest coefficient of thermal expansion of any of the stainless steels, very close to that of glass, it is useful for metal-to-glass seals. Type 446 can be drawn satisfactorily, and much of it is so formed. It is used extensively for oil burner parts. As it is ferritic, it is nonhardenable by heat treatment. The metal is annealed by heating to 1500 to 1600 F and cooling in air. Strength in the annealed condition: tensile strength, 80,000 psi; yield strength, 50,000 psi; elongation in 2 in., 25%.



Cold forming stainless steel army canteen cups by the relatively new Hydroforming technique. Left shows a 9½-in. dia blank from which the cup, right, is formed in one operation. Conventional methods would usually require three operations. Blank is 0.025 in. thick; drawn cup is 5¼ in. deep. (Cincinnati Milling Machine Co.)

Cold Forming Methods

Drawing

All annealed stainless steels have properties that indicate fair to good drawability. They have good tensile strength, a moderate yield point, and good elongation. As compared to a mild steel deep drawing grade, most grades of stainless steel will have higher tensile strength, about the same yield point, and equal or higher elongation. A comparison of these properties for several typical steels is as follows:

	Tens Str, Psi	*Yd Str, Psi*	*Elong, %*
Deep draw., carbon steel	45,000-55,000	30,000	30-35
Type 410 Stainless	65,000	35,000	25-30
Type 302 Stainless	75,000	30,000	50-60

Because all the stainless steels tend to work harden rather rapidly, and flow sluggishly, considerably more power is required to form them than is required for mild steel. Some of the grades work harden more rapidly than others, and so may need special care, such as less severe draws with an additional anneal between them.

Power requirements for drawing stainless steels are approximately double those for mild steels. Reducing the speed of the draw to about one-half that for plain carbon steels will permit the stainless steel to flow to a greater depth, and will decrease the rejects caused by tearing of the metal. The danger of scoring the dies will be lessened also. A speed of 20 to 25 ft per min has been suggested.

The blank should be of sufficient diameter to retain a flange on the drawn shell. Pressure pads should be adjusted to exert greater pressure on the blank, so that the metal flowing into the draw ring will not wrinkle or fold. Draw beads are a help in some cases.

A thorough anneal is desirable for any cold working of stainless steel, and especially for deep drawing applications. The hardness should not exceed 85 Rb for light forming or bending, and a maximum hardness of 80 Rb is preferred for deep drawing.

Clearance between punch and draw die should be about twice that for plain carbon steel, and in some cases may be as much as three times the figure for the unalloyed material.

The grades with relatively high nickel content, in general, are less susceptible to work hardening than the low nickel alloys. More particularly, the austenitic stainless steels have definitely better drawability than the ferritic or martensitic grades. The approximate maximum reductions to be expected from the three classes are:

Austenitic types—40%
Ferritic types—30%
Martensitic types—25%

This means that, starting with a blank 10-in. dia, it should be possible to draw a cup 4 in. deep in one operation with the austenitic grades, 3 in. deep with the ferritic types, and 2 in. deep with the martensitic materials. These values are only approximate, of course, as there are many factors influencing the drawability of a specific material on any job. In addition to the variation from grade to grade within each type, the gage of the steel, the lubricant used, the speed of the punch, and the condition of the dies and of the surface of the stock will change the draw capabilities considerably.

When deep drawing ferritic types, heating the material to about 200 to 300 F greatly increases ductility, especially at the beginning, of the draw.

Blanking, Shearing, Punching

Blanking and shearing are usually preliminary to other forming operations, and are most frequently performed upon flat stock—sheet, plate or strip. Punching is also most used with flat stock. These operations are of somewhat greater importance in the fabrication of stainless steel than

with plain carbon steels or the lower-alloyed steels. Whereas flame cutting is often used in milder steels, it is not widely applicable on the stainless steels. Although stainless steels can be flame cut, it involves the use of a metallic flux or powder with the flame, and does not produce as clean a cut as with mild alloyed steel.

The toughness of stainless steels as compared to carbon steel makes necessary the use of more powerful equipment for blanking or shearing. The excess shearing capacity over the requirement for mild steel has been estimated at from 30 to 50%. Other than this requirement for heavier equipment, the stainless steels present no difficulty in shearing. Blades should be preferably of high-speed steel, and should be ground with the greatest lip clearance that can be maintained without chipping. Sharp blades are essential to clean cutting. Dull blades will tend to drag the metal, and with light gage stock may turn over the edge instead of cutting it.

Blades must have closer adjustment for stainless steels than for carbon steels. It is necessary to cut them deeper to prevent burred edges. A clearance between shear blades of 1/10th of the thickness of the stock being sheared has been suggested, though this is largely a matter of experience in the shop. Slitting stainless steel coils is closely related to shearing. The slitters must be sharp and coil tension maintained carefully during the run.

Burrs resulting from shearing should be removed carefully. The burrs are work hardened during their formation, and may scratch or gouge the surface of the die or the pressure pad, and may interfere with the flow of metal over the die surface during forming operations.

In blanking or punching stainless steel, slower press speeds than those for mild steel are advisable. More power is required. Punches and dies should be of the best tool steel, and should be kept very sharp.

Opinions are divided as to the clearance to be maintained between punch and die for best results. Some authorities suggest that the martensitic and ferritic grades of stainless steel can be satisfactorily blanked or punched with the same die clearances used for plain carbon steel. Others recommend that die clearance be much closer. It is generally agreed that the chromium-nickel grades are punched cleanest when the die clearance is closer than that for mild steel.

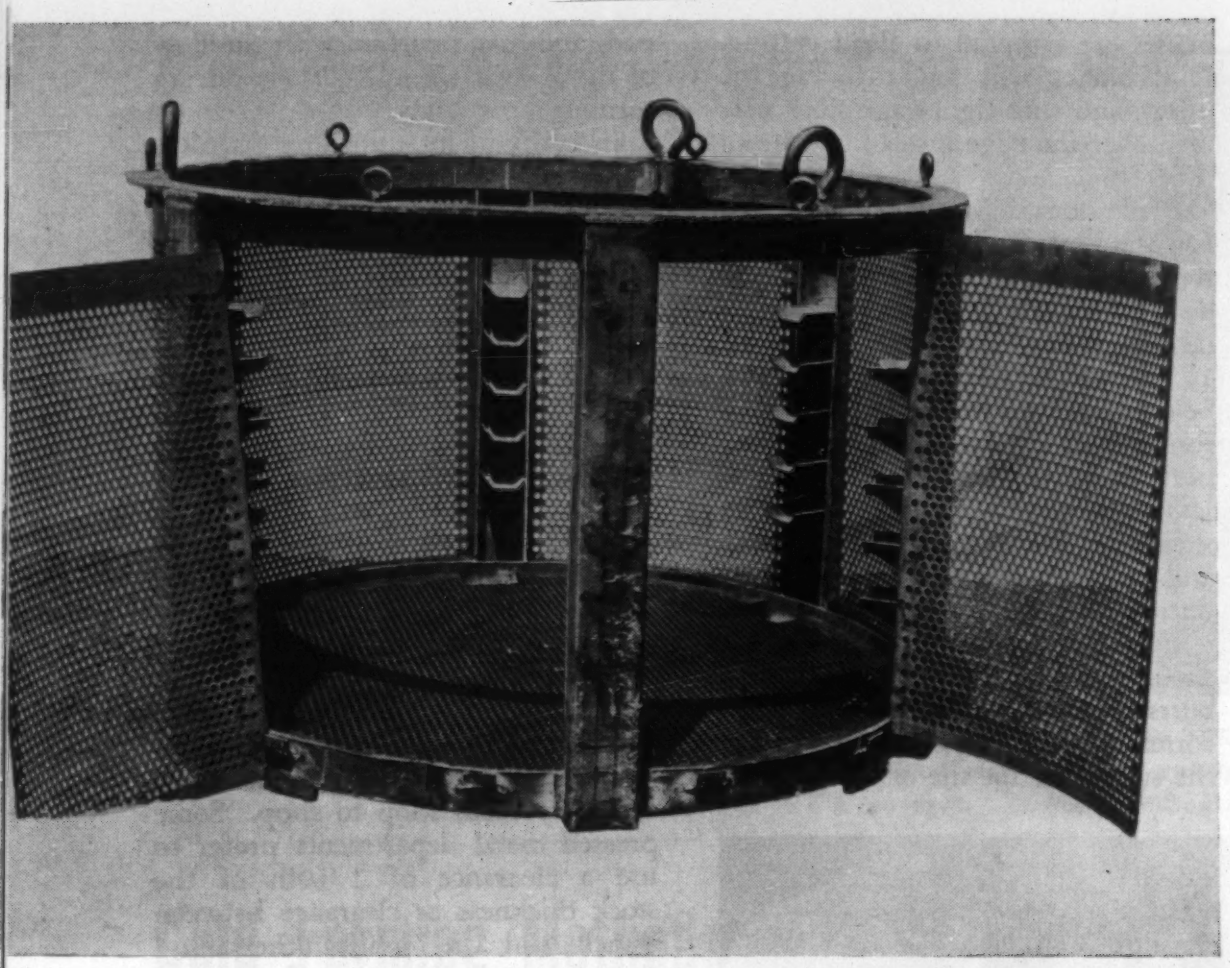
Die clearances giving best results will vary from shop to shop. Some pressed metal departments prefer to use a clearance of 1/10th of the stock thickness as clearance between punch and die, while others find that standard clearances of 0.001 to 0.0015 in. for light gages and 0.0015 to 0.002 in. for heavy gages give satisfactory results. Dies with excessive clearance tend to drag the metal between punch and die. The subject of die materials will be discussed later.

While stainless steels can be readily blanked, sheared and punched, their toughness usually requires more powerful equipment as compared to carbon steel. (U. S. Steel Co.)

Perforating

As perforating is really an elaboration of punching, most of the information given for the latter operation is applicable to the former also. Perforating is performed on special machines that punch an entire row of holes, sometimes several rows, at a single stroke of the machine. The sheet is then advanced automatically to the position for the next stroke. The result is a sheet of stainless steel containing many rows of holes evenly spaced according to a predetermined pattern. Such sheets are used for filter screens, grilles for radio receivers, ventilator registers, separators and trays.

All grades of stainless steel can be perforated, and many of the chromium-nickel compositions are fabricated by this means for use in the chemical industry. There are no special precautions to be taken, and only a few changes from procedure used for perforating mild steel. Punch clearances should be held much closer than for mild steel, and because the power requirement is



All grades of stainless can be perforated. Such sheets are used for filter screens, grilles, trays and similar products. (Armco Steel Corp.)

greater, it may be necessary to reduce the machine speed. Punches should be kept sharp. Arranging the punches on stepped levels, so that they meet the work successively, will lessen the peak power requirement.

The smallest holes that can be punched in stainless steel on perforating machines are of a diameter about twice the thickness of the sheet being perforated.

Press or Brake Forming

Press forming and brake forming of metals involves bending and shaping without drawing. Stainless steels form well in such operations, but some special consideration must be given to their characteristics.

Presses or brakes used on stainless steels, but rated on the basis of mild steel, should have a rated capacity about twice the gage of the stock used. That is, a machine having a capacity rated for mild steel should not be used for stainless steel thicker than about half the maximum recommended gage in mild steel.

Radii should be somewhat larger than for mild steel. Springback allowance will vary with the grade of stainless steel used, the extent of work hardening resulting from prior operations, and the gage of the metal; also, springback will vary with certain factors in the bending operation itself, such as the speed of bending. In general, the springback allowance should be two to three times that for plain carbon steels.

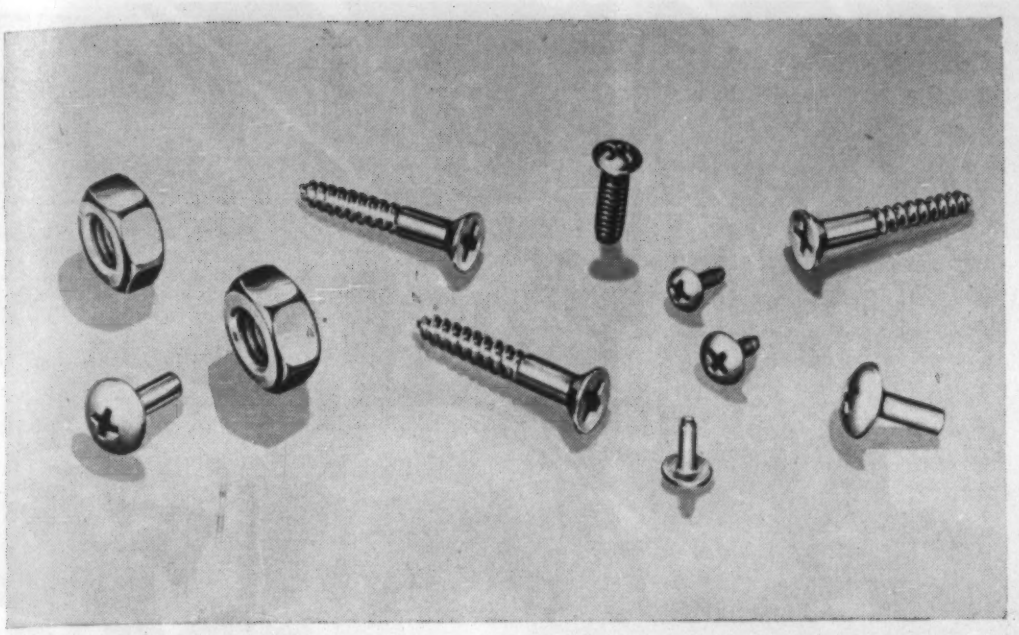
When polished sheets are to be formed in a brake, or occasionally in a press, and the working of the metal will not be severe, the finish can frequently be preserved by attaching strips of adhesive tape to the contact edges of the brake or surfaces of the die. The same cause may be served by adhering sheets of waxed or oiled paper, or of ordinary newspaper, to the steel itself. Use of a rubber adhesive will permit stripping the paper from the metal after the work has been completed.

A lubricant should be used with most forming operations with stainless steel, in addition to the use of paper or other protective measures.

Cold Heading

The process of cold upsetting of wire or rod to form a head or other

Press or brake forming is a common cold forming method for stainless steels. Such an operation is being performed on a sink top at Pride Manufacturing Co. (U. S. Steel Co.)



While practically all grades of stainless can be cold headed, a special chromium-nickel austenitic type that work hardens more slowly than conventional 18:8 has been developed by Carpenter Steel Co. for parts like these.

shape is used for the large scale production of parts such as bolts, nails, screws, rivets, cotter pins, etc. The head can be formed in either open or closed dies. As the parts are of simple form, the entire sequence of fabricating operations is quite simple. After heading, the material is cut to the proper length in the same machine, and the head may or may not be slotted, depending upon the design. The threads, if any, are next roll formed on the part, and it is complete.

An acid dip to passivate the stainless steel customarily follows fabrication. An anneal before thread rolling is sometimes advisable to lengthen the service life of the thread rolls.

While all grades of stainless steel can be cold headed, by far the greatest amount of steel used is of two grades—Type 410 in the martensitic grades and 302 in the austenitic grades. Both of these alloys are furnished as annealed wire or rod, in coils, and coated with a suitable lubricant, especially for cold heading.

Type 410 is slightly lower in cost, somewhat harder to work, but is somewhat lower in corrosion resistance than Type 302. However, Type 410 parts have ample corrosion resistance for architectural and other applications where they need resist only weathering, and the price differential gives them an advantage.

Where fasteners will be subjected to more severe corrosive conditions, as in chemical equipment or in food processing, the 302 material in the popular 18:8 composition will be chosen. Its cost is higher, but it is easier to fabricate, so that overall cost may be quite close to that of the straight chromium stainless part.

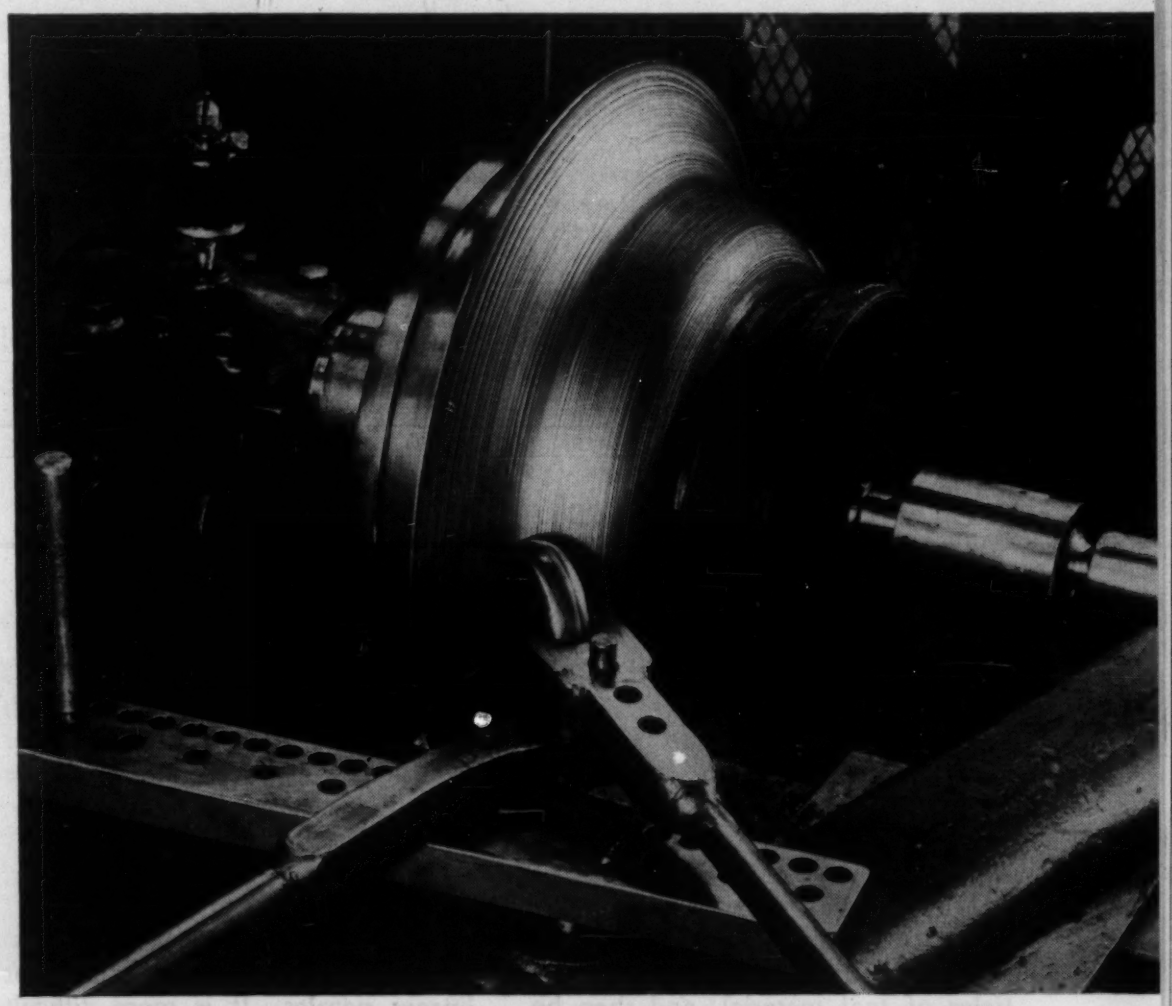
Special requirements occasionally result in choosing stainless steels of other types for the cold heading process. All of the types for which there is any demand can be formed without difficulty. While metal is severely worked during cold heading, the operation is performed in one quick action, so that work hardening does not greatly affect the process.

Spinning

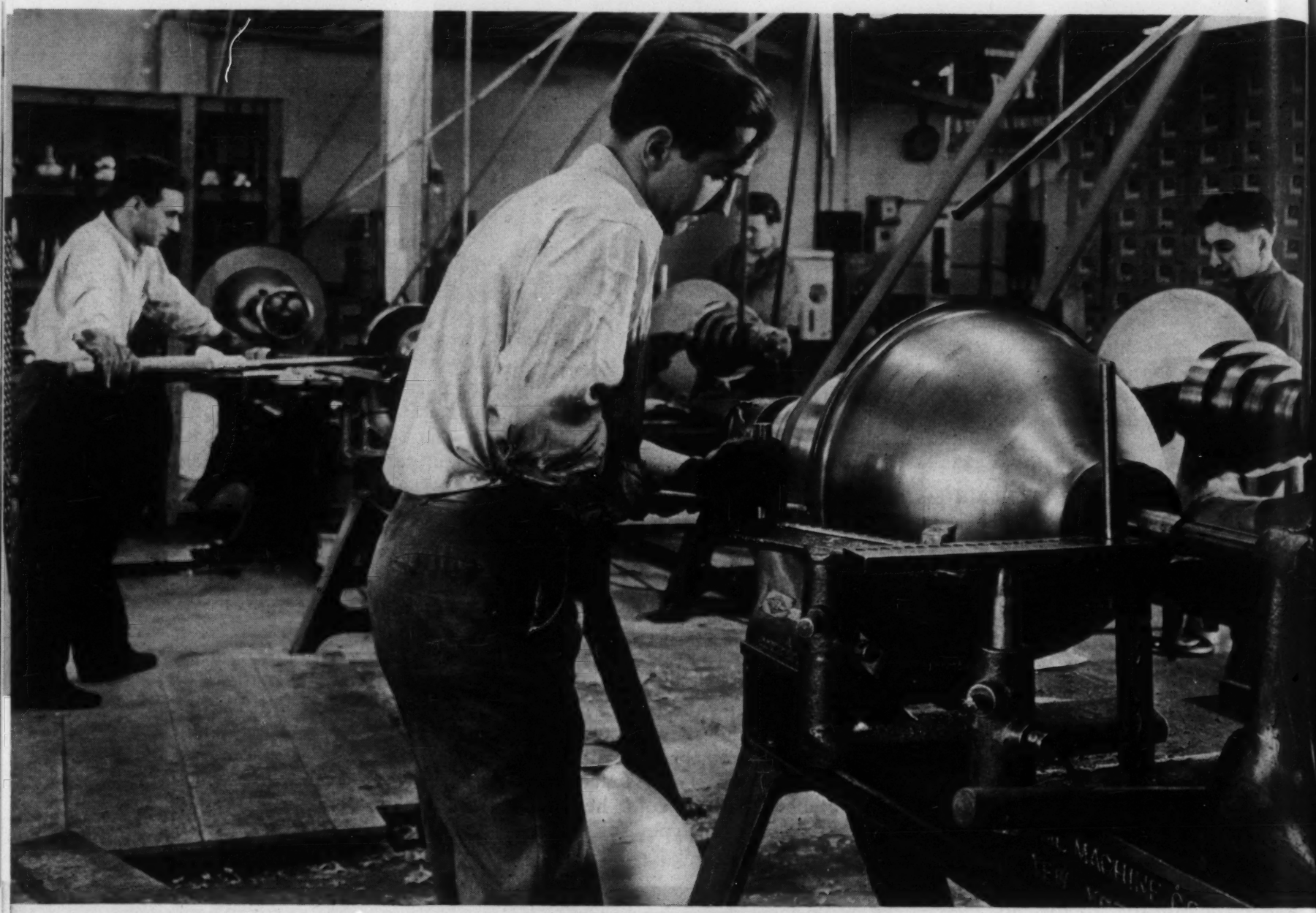
Spinning is now a standard method of fabrication for stainless steels. Tools and equipment are practically the same as those used for spinning mild steel or copper; however, more power is required than for the spinning of mild steel. The spinning tool may be of the bar or roll type, and the design should be similar to that used for spinning copper, except that the bearing surface should be greater.

Austenitic stainless steels should be spun at a speed about one-fourth to one-half that for copper or other soft metals. The spinning cannot be carried to the depth obtainable with the softer metals, and anneals must be more frequently made.

The martensitic and ferritic grades can usually be spun at about two-thirds the speed suitable for plain carbon steels of the same gage. These stainless steels can be spun only about one-third as much before an-



Spinning stainless steel shapes is now a common forming method. (Armco Steel Corp.)



Expert workmen spinning lighting reflectors (Curtis Lighting, Inc.)

nealing is required, however.

The spinning operation should be carried out so that the metal is deformed by tensile stresses, if possible. If the design permits, 1 or 2 in. of rim metal should be left outside the worked area until spinning is completed, to prevent cracking or splitting from the outer edge. If the piece shows a tendency to wrinkle along the outer edge during the spinning, due to working hardening, a flange can be turned up at the edge of the blank and the piece then spun from the center out in the usual way. The flange is removed and the edges smoothed before spinning the edge itself.

Trimming can be done best with a rotary type cutter, and at reduced speed. Where a rotary cutter is not available, a regular cutting tool of high-speed steel can be used.

It is important that the spun metal be cleaned thoroughly to remove all traces of spinning lubricant or particles of tool material, and then be annealed promptly. Delay in annealing after severe cold working may result in the piece cracking within a few hours.

The austenitic types are in general easier to spin than the martensitic or ferritic compositions. The austenitic grades most used are listed below.

Type 302—The basic 18:8 composition. Lowest in cost of the highly-alloyed grades; spins well.

Type 304—A weldable grade, carrying a few cents premium over the basic 18:8 type.

Type 305—A special spinning grade. Best spinning properties of the austenitic stainless steels; carries a few cents premium in cost, which can often be saved by the greater depth to which the metal can be spun before annealing is necessary, or by eliminating an anneal.

Type 308—A heat resistant grade, slightly more difficult to spin.

Type 309—A special high temperature material frequently used for burner nozzles. It is more difficult to spin than the basic 302 alloy, and carries a price premium of about 14¢ per lb.

Type 310—Another high temperature grade often used for furnace parts.

Type 316—A chemically resistant grade, carrying a price premium of about 15¢ over the basic 18:8 material.

Type 317—Another chemically resistant grade.

Type 321—A stabilized 18:8 alloy, for use where welding with possibility of subsequent stress relieving enters into the fabrication, or where part may encounter continued high temperatures in service.

Type 347—A stabilized 18:8 largely used in aircraft engine parts. It carries a price premium of about 12¢ over the basic grade.

The ferritic and martensitic grades are spinnable, but because of the better formability of the austenitic grades they are not as widely used as the chromium-nickel types. The few grades which provide the bulk of the material for spinning are

listed below.

Type 410—Hardenable by heat treatment, it can be formed in the annealed condition and then treated to high strength. It is lower in cost than the chromium-nickel grades.

Type 414—To improve the corrosion resistance of the basic 410 grade, the 414 alloy has a few percent of nickel added.

Type 420—A high carbon type intended for heat treatment to high strength.

Type 430—The standard spinning grade among the higher chromium content ferritic steels. It is frequently used for elevated temperature service because of its good resistance to corrosior at high temperatures.

Type 446—A ferritic stainless steel of high chromium content intended for service at elevated temperatures. It has high scaling resistance. It can be spun without any particular difficulty.

Draw Rolling

A cold forming method for stainless steels having rather specialized applications is draw rolling. In this process strip or narrow sheet stock is drawn through steel forming rolls to force it into a desired shape. It differs from press forming in that the rolls will turn, permitting slippage and eliminating the dragging of the metal over the forming surfaces. It differs from cold rolling in that the rolls do not drive the metal. The metal is formed without strain and resulting change of thickness. While the rolls are idlers, fixed dies are sometimes used as straighteners after the roll pass. Forming can be completed in one pass through the rolls, or in several passes through a series of rolls. Three stands of rolls are the usual number.

Draw rolling is practically confined to the fabrication of members for aircraft construction, truck parts, railroad car trim, masts, etc. The materials used are austenitic stainless steels. The method is also used to produce pieces of small section, such as channels or angles, where the quantity is too small to warrant special equipment for the usual hot rolling. Thin gage stock is used, with thicknesses of from 0.002 to 0.030 in. the usual range. While rather complicated sections can be formed, it is usually most economical to draw symmetrical sections of simple form and to join these by spot welding into more elaborate pieces.

When forming a piece from a flat strip, the operation should begin at or near the center line of the strip, and work outward toward the edges in successive passes. Bends of more than 45 deg should not be attempted in any one pass. Edge guides can be used for the first pass, and the formed section will guide the piece through succeeding rolls.

Forming rolls can be solid, or they can be built up with a solid central section and flanges bolted onto it. The assembled roll is more costly, but has the advantage of greater flexibility in use. The spacing of the flanges can be changed by means of shims, or the flanges themselves are replaced. The rolls are made of case hardened, cold rolled steel, or, if service is to be severe, of hardened tool steel. It is important that the rolls be made with the largest radii permitted by the design of the piece to be formed, and that the surfaces be smoothly finished, preferably burnished.

Roll forming containers for chemicals and foodstuffs from Type 347 stainless. (Armco Steel Corp.)

Processing Materials and Annealing Procedures

Tool and Die Materials

Dies for drawing stainless steels are made from a variety of materials, depending upon the severity of service and the length of the run. Solid dies made from high carbon, high chromium tool steel are satisfactory for most service. Ordinary cast iron dies can be used for short runs, but alloy cast iron dies containing chromium and nickel will give longer life.

Dies for experimental forming, as in aircraft work, can be made at low cost by casting zinc alloys in plaster molds. Such dies are suitable for use with light sheet stock, and are especially useful where changes in the dies may be necessary. Male forming dies of zinc alloys can be used in forming presses or drop hammers, operating against a rubber mat.

When using dies of easily fusible alloys, special care must be taken to clean the work thoroughly of all trace of zinc or lead, as any subsequent heating of the metal will cause embrittlement if even small amounts of the die alloy have been picked up during forming. Pickling in warm nitric acid, 10 to 20% strength, will dissolve any surface particles of these metals.

Bronze dies are favored in much stainless steel drawing, because when unlike metals are used in die and workpiece, there is less possibility of galling. Aluminum bronze, one of the hardest of the low price bronze alloys, is a frequent choice because of its longer life. Because the primary advantage of bronze dies is low friction of the blank over the die block, use of bronze is confined to female dies and the pressure pads. Punches or male dies can be of steel or cast iron. Bronze dies should be set in die blocks of steel or cast iron also, to back up the die and reduce spring. In such dies the bronze insert should be as large in diameter as the blank, to avoid uneven drawing of metal when the blank ceases to bear on the steel portion of the block.

An added advantage of bronze dies in the drawing of stainless steel is the opportunity of using smoother polished stock without marring the finish. Even in large steel dies it has been found that corner blocks of bronze inserted in the die reduces the tendency toward corner wrinkling or dog-earing. Draw beads of bronze can be inserted in the block also when necessary.

In the spinning of stainless steels, rotary tools are preferred where a choice is possible, because of lower friction and less work hardening of the steel. The tools can be of hardened alloy steel or of alloy cast iron. Recent practice favors facing the ferrous metal tool with arc deposited bronze, especially where a smooth finish on the work is essential.

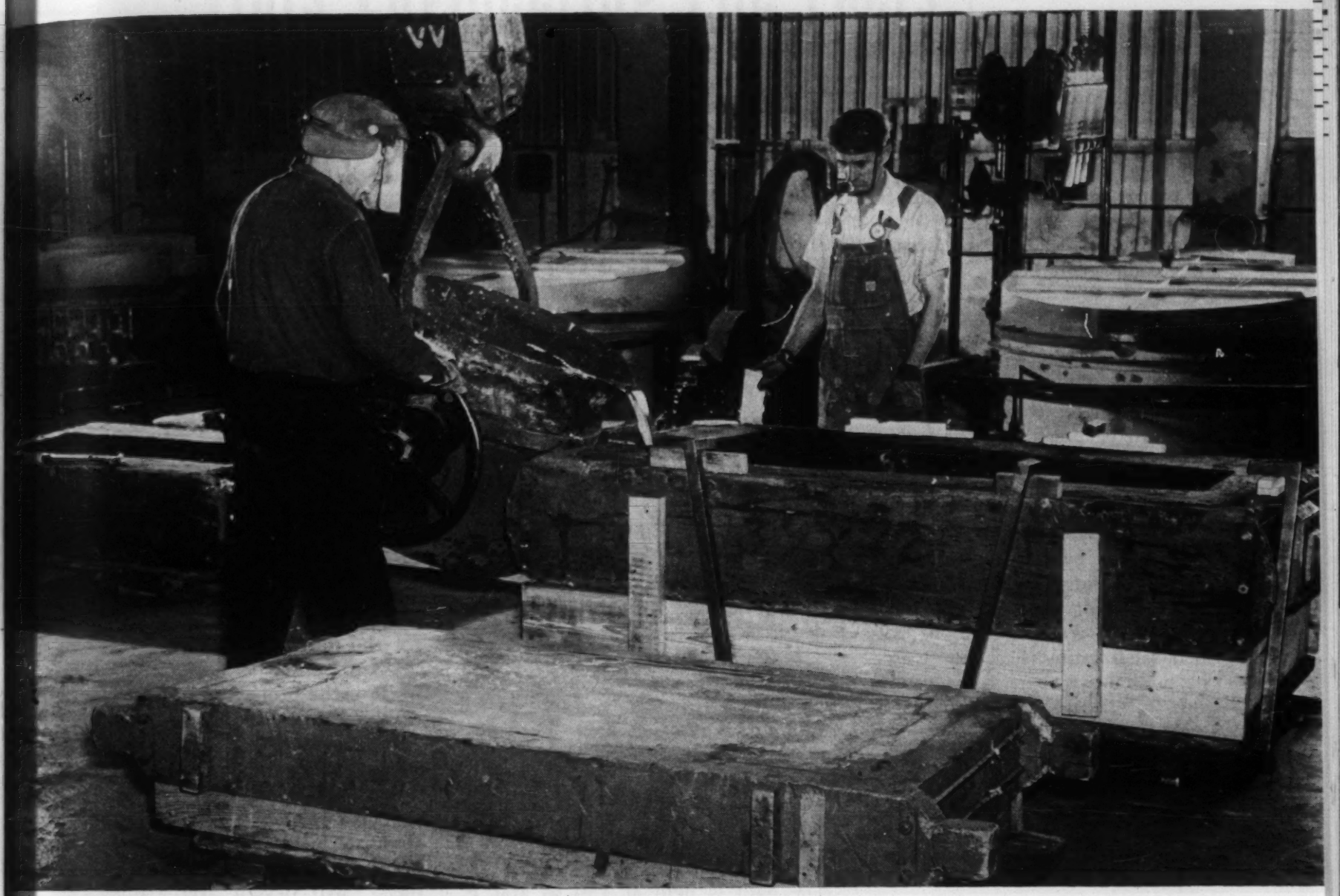
When copper or cuprous alloy tools have been used in the forming of stainless steels, a nitric acid pickle should be used to remove traces of the foreign metal before annealing or otherwise heating.

Lubricants

Proper lubrication of the work is of prime importance in drawing and spinning operations. Lubricants are, in general, either oil-base or soap-base types. Films of plastic or latex also function as lubricants in some cases, though used primarily as protective coatings. Whatever lubricant is used, it must have high film strength and good adhesion. Oil-base compounds may make use of petroleum oils, vegetable oils such as linseed oil, or animal fats. They are

Annealing Data for Stainless Steels

AUSTENITIC STAINLESS STEELS	
Process anneal	Heat to 1750 F for 18:8 compositions. Time: 30 to 60 min at temperature for heavy sections, 15 to 30 min at temperature for light sections. Cool rapidly, by water quench for heavy sections, 1/8 in. or heavier, in water or in air blast for lighter sections.
Full anneal	Preheat to 1500 to 1600 F and soak. Heat rapidly to 1900 to 2000 F for 18:8 compositions, to 1900 to 2050 F for 25:12 and 25:20 alloys. Time: 30 to 60 min at temperature for sections over 1/8 in., 15 to 30 min at temperature for sections 1/8 in. and under. Cool rapidly, by water quench if possible, for all sections; air blast permissible with light sections.
FERRITIC STAINLESS STEELS	
Annealing or stress relieving	Heat to 1400 to 1500 F for types below 17 chromium content, to 1550 to 1650 F for higher-chromium types. Time: 1 hr or more per in. of section. Cool in air for types below 17% chromium, rapidly (water quench if possible) for high-chromium types.
MARTENSITIC STAINLESS STEELS	
Process anneal	Heat to 1300 to 1400 F. Time: soak thoroughly, about 1 hr per in. of section, cool slowly in air.
Full anneal	Heat to 1550 F. Time: soak thoroughly, about 1 hr per in. of section. Cool slowly in furnace to about 1100 F, then air cool.



Zinc casting alloys are frequently used for dies for experimental work or for forming light sheet stock. (North American Aviation, Inc.)

sometimes sulfurized, especially for difficult work, and can be diluted to the desired consistency with kerosene. Soap emulsified in oil is also used.

When draws are light or the forming is not severe, water-base preparations are useful. Some of these are: Lithopone mixed with water, powdered graphite mixed with water, water soluble emulsions, and water soluble soaps. Lithopone or white lead in linseed oil, or preparations in castor oil or corn oil, are other compounds used.

Thorough cleaning of the work after any forming operation and before annealing is necessary if damage to the stainless steel is to be avoided. Water soluble lubricants are usually removed without difficulty by a warm water rinse or by jet washing. Oil-base lubricants require an organic solvent degreasing, or use of an alkali cleaner, or both. Soap-base types can sometimes be removed in hot water, but insoluble soaps require an organic solvent cleaner.

Any lubricant remaining on the surface of the work when it goes into the annealing furnace or is otherwise subjected to heat will cause carburization of the steel, pitting of the surface, and lowered corrosion resistance at that point. Even finger prints can be burned into the surface of the steel during annealing.

Annealing Procedures

Annealing operations have been outlined in other manuals in this series, but are so important to cold working that they will be mentioned briefly here also.

Stainless steel for most cold forming is supplied in the fully annealed condition, but it is usually necessary to re-anneal the metal at least once in the course of processing. It is not always necessary to fully anneal the work between draws or other forming operations, however; the lower temperature anneal, called the process anneal, is frequently satisfactory. This is really a stress relieving operation, but it serves to increase the ductility sufficiently to permit additional working without cracking the piece. Temperatures for full annealing and process annealing have been given in a previous section.

A muffle or other indirect heated furnace is best for annealing stainless steels. Heating in an open flame will usually cause some carburization of the metal. A reducing atmosphere tends to cause carbon pickup also. Excess oxygen in the atmosphere should be avoided, however. Box annealing can be used for martensitic steels of less than 14% chromium content, as these steels require slow cooling following the anneal. Box annealing is unsuitable for the other types, which must be cooled rapidly.

Excessive temperature, or heating at correct temperature for an extremely long time, encourage grain growth in the steel, and may show up as orange peel upon subsequent cold working. The time required for annealing depends upon the thick-

ness of section, also upon the temperature, and no exact figures can be given. One method for heating to insure a proper heat distribution throughout the piece is to preheat at a moderate temperature, soak for an ample period, then heat rapidly to the proper annealing temperature for a short period.

Some annealing data are given in the accompanying table.

Cleaning and Polishing

After annealing, and especially if the annealing has been done in an atmosphere rich in oxygen, a light scale will be present on the surface of the work. If the piece has been welded, a patch of scale may surround the weld area. Light scale over a small area can sometimes be removed best by wire brushing with a brush having wires of stainless steel. Heavier scale may require sandblasting. For pieces to be polished, sandblasting is sometimes used as a preliminary operation. Quantity work, or pieces of large area, can usually be cleaned most efficiently by pickling.

There are several pickling solutions—mixtures of strong acids—for stainless steel. Light scale can be removed by a hydrofluoric acid pickle composed of:

Hydrofluoric acid—
1 to 4 parts by vol.
Conc. nitric acid—
8 to 20 parts by vol.
Water, to make 100 parts by vol.

This is used at 130 to 150 F.

In cases where the scale is very heavy, the work can be treated first with a pickle composed of:

Conc. sulfuric acid—
6 to 8 parts by vol.
Conc. hydrochloric acid—
2 to 4 parts by vol.
Water, to make 100 parts by vol.

This bath, used at 140 to 160 F, will soften and loosen the scale so that it can be removed in the second bath.

For the martensitic and ferritic grades, the following bath may be preferred:

Conc. sulfuric acid—
10 parts by vol.
Roch salt—¼ lb. per gal.
Water, to make 100 parts by vol.

Used at 160 to 180 F, this bath works well with the straight-chromium grades and is also useful first bath for loosening scale on the austenitic types. A nitro-hydrochloric acid bath that can be used to follow the above pickle is composed of:

Conc. nitric acid—3 parts by vol.
Conc. hydrochloric acid—
25 parts by vol.
Water, to make 100 parts by vol.

The best operating temperature for this bath is 140 to 160 F. It produces a bright finish, especially if a commercial inhibitor is added to the mixed acids.

A pickle quite useful in removing the light scale that forms on stainless steels during annealing is composed of:

Caustic soda—20 parts by wt.
Potassium permanganate—
5 parts by wt.
Water, to make 100 parts by wt.

Used at its boiling temperature, about 230 F, it is adequate for removing light scale, and can serve as a preliminary bath in removing denser scales.

If mechanical cleaning has been used, the work should be given a nitric acid treatment to insure passivation of the cleaned area. The solution used for austenitic alloys and for the ferritic types is:

Conc. nitric acid—
20 to 40 parts by vol.
Water, to make 100 parts by vol.

The bath is held at 130 to 160 F and the work is immersed in it for 30 to 60 min. For highly polished ferritic alloys, the temperature is held to the low side of the range given, and the concentration of nitric acid is increased to 50% by volume.

Martensitic alloys can be passivated by immersing in the following bath, at room temperature for about 60 min, or at 130 F for about 15 min.:

Conc. nitric acid—70 parts by vol.
Water, to make 100 parts by vol.

An alternative treatment uses a lower concentration of acid, 15 to 30% by volume, and adds about 2% by weight of sodium dichromate to it. This is used at about 110 to 140 F for about 30 min. Reducing the concentration of nitric acid to 1%, and the sodium dichromate to ½%, and using at temperature near the boiling point, reduces the danger of pitting on polished surfaces.

Formed pieces can be ground if a weld bead or imperfection must be removed, and a solid abrasive wheel is used. For development of a better surface, however, a series of polishing operations, using fabric wheels charged with abrasives, are standard procedure. Lubricated abrasives give a smoother finish for the same grit number than dry abrasives. Standard grit sizes range from about No. 60 to about No. 320, and it is good practice to use successively finer abrasives by about 40-number intervals in a polishing operation. Abrasives for stainless steel should be iron free, and should not be used on other metals.

Lubricants are usually compounds of animal fats, such as mutton, tallow and stearic acid. In general, harder lubricants give softer finishes with a given grit size.

For the higher finishes, the rotating brush of tampico fiber, with a fine abrasive and oil, can be used. These fine finishes should be started from a No. 4 finish. A buffing wheel, made from a high count muslin or linen, and charged with a fine abrasive of levigated alumina or chromic oxide, is used at high speed for the mirror finishes.

As important as developing a fine finish is the protection given it. Some of the devices used have been suggested in connection with discussion of processes, such as the use of adhesive tape along the edges of brakes, use of newspapers as coverings for steel sheets, etc. Felt pads on the hold downs when working polished metal will lessen the danger of scratching. The cleanliness of the sheets or other stock, and of the dies of forming devices, is another means of reducing the scratches that mar fine finishes.

Flexible coatings of rubber latex or of plastics lacquers are useful both as protection for polished stainless steel during handling and as a combination protection and lubricant during forming. These jellylike finishes provide excellent protection even during heavy pressing, but can be stripped off with the fingers after the processing is completed, eliminating the cleaning problem.

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Acknowledgments

The personnel or publications of the following companies were consulted in the preparation of this manual:

Allegheny Ludlum Steel Co.
Armco Corp.
The Budd Co.
Carpenter Steel Co.
Crucible Steel Co.
Leake Stamping Co.
Phoenix Products Co.
Republic Steel Corp.
United States Steel Corp.
Worcester Pressed Steel Co.

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Materials Engineering File Facts

Summary of Standard Specifications for Steel Castings

Revised Apr. 1, 1952

ASTM	A 27-50 T Mild to Medium-Strength Carbon-Steel Castings for General Application (Tentative).
ASTM	A 148-50 T High-Strength Steel Castings for Structural Purposes (Tentative).
ASTM	A 95-44 Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service.
ASTM	A 216-47 T Carbon Steel Castings Suitable for Fusion Welding for Service up to Temperatures of 750 F.
ASTM	A 217-49 T Alloy Steel Castings for Pressure Containing Parts Suitable for High Temperature Service.
ASTM	A 352-52 T Ferritic Steel Castings for Pressure Containing Parts Suitable for Low Temperature Service.
SAE	1946 Automotive Steel Castings (Tentative).
AAR	M 201-47 Steel Castings.
AREA	Specifications for Steel Railway Bridges 1949: Steel Castings.
FEDERAL	QQ-S-681b (11-6-1941) Steel Castings (Amended 8-24-1943).
MILITARY	MIL-S-15083 (Ships) Apr. 1950 Steel; Castings. Superseding 49S1 (Ships). (Amended 11-1-1950).
MILITARY	MIL-S-870 (Ships) Sept. 1949 Steel, Alloy, Molybdenum; Castings. Superseding 46S33 (INT).
MILITARY	MIL-S-15464 (Ships) Dec. 1950 Steel, Alloy, Chromium-Molybdenum; Castings.
American Bureau of Shipping Steel Castings 1952 Rules Edition—Machinery and Hull Castings.	
Lloyd's Register of Shipping 1951—Steel Castings.	

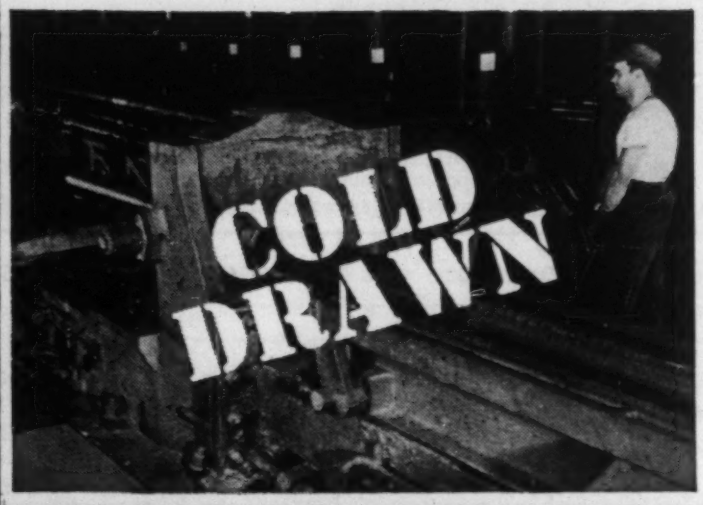
SPECIFICATION AND HEAT TREATMENT			MECHANICAL PROPERTIES—MINIMUM					CHEMICAL COMPOSITION %—MAXIMUM								
Spec	Class	(#) Heat Treatment	Ten Str, 10^3 Psi	Yld Pt, 10^3 Psi	Elong in 2 In, %	Red. of Area, %	Other Tests: Bend, Impact Hardness†	C	Mn	P	S	Si	Cu	Ni	Cr	Other Elements
ASTM A 27-50T	N-1	—	—	—	—	—	—	.25[2]	.75[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
	N-2	A, N, NT, QT	—	—	—	—	—	.35[2]	.60[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
	N-3	A, N, NT, QT	—	—	—	—	—	—	1.00	.05	.06	—	—	—	—	—
	U-60-30	—	60	30	22	30	—	.25[2]	.75[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
	60-30	A, N, NT, QT	60	30	24	35	—	.30[2]	.60[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
	65-30	A, N, NT, QT	65	30	20	30	—	—	—	.05	.06	—	—	—	—	—
	65-35	A, N, NT, QT	65	35	24	35	—	.30[2]	.70[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
	70-36	A, N, NT, QT	70	36	22	30	—	.35[2]	.70[2]	.05	.06	.80	.50[3]	.50[3]	.25[3,4]	W .10
ASTM A 148-50T	80-40	A, N, NT, QT	80	40	18	30	—	—	—	.05	.06	—	—	—	—	—
	80-50	A, N, NT, QT	80	50	22	35	—	—	—	.05	.06	—	—	—	—	—
	90-60	A, N, NT, QT	90	60	20	40	—	—	—	.05	.06	—	—	—	—	—
	105-85	A, N, NT, QT	105	85	17	35	—	—	—	.05	.06	—	—	—	—	—
	120-95	A, N, NT, QT	120	95	14	30	—	—	—	.05	.06	—	—	—	—	—
	150-125	A, N, NT, QT	150	125	9	22	—	—	—	.05	.06	—	—	—	—	—
	175-145	A, N, NT, QT	175	145	6	12	—	—	—	.05	.06	—	—	—	—	—
ASTM A 95-44	—	A, N, NT	70	36	22	30	Bd—deg [90]	.15-.45	.50 min.	.05	.06	.20 min.	—	—	—	—
ASTM A 216-47T	WCA	A, NT	60	30	24	35	[90]	.25[5]	.70[5]	.05	.06	.60	.50[5]	.50[5]	.25[5]	Mo+W.25[5]
	WCB	A, NT	70	36	22	35	[90]	.35[5]	.70[5]	.05	.06	.60	.50[5]	.50[5]	.25[5]	Mo+W.25[5]
ASTM A217-49T	WC1	A, NT	65	35	24	35	[90]	.25	.50-.80	.05	.06	.60	.50[6]	.50[6]	.35[6]	Mo .45-.65
	WC4	A, NT	70	40	20	35	[90]	.20	.50-.80	.05	.06	.60	.50[6]	.70-1.1	.50-.80	Mo .45-.65
	WC5	A, NT	70	40	20	35	[90]	.20	.40-.70	.05	.06	.60	.50[6]	.60-1.0	.50-.90	Mo .90-1.2
	WC6	A, NT	70	40	20	35	[90]	.20	.50-.80	.05	.06	.60	.50[6]	.50[6]	1.0-1.50	Mo .45-.65
	WC9	A, NT	70	40	20	35	[90]	.18	.40-.70	.05	.06	.60	.50[6]	.50[6]	2.0-2.75	Mo .90-1.2
	C5	A, NT	90	60	18	35	[90]	.20	.40-.70	.05	.06	.75	.50[6]	.50[6]	4.0-6.50	Mo .45-.65
	C12	A, NT	90	60	18	35	[90]	.20	.35-.65	.05	.06	1.00	.50[6]	.50[6]	8.0-10.0	Mo .90-1.2
ASTM A 352-52T	LCB	N, NT, QT	65	35	24	35	Imp—ft-lb 15[7]	.30[5]	.70[5]	.05	.06	.60	—	—	—	—
	LC1	N, NT, QT	65	35	24	35	15[7]	.25	.50-.80	.05	.06	.60	—	—	—	Mo .45-.65
	LC2	N, NT, QT	65	40	24	35	15[7]	.25	.50-.80	.05	.05	.60	—	2.0-3.0	—	—
	LC3	N, NT, QT	65	40	24	35	15[7]	.15	.50-.80	.05	.05	.60	—	3.0-4.0	—	—
SAE Automotive	0022	A, N, NT	—	—	—	—	Bhn —	.12-.22	.60[2]	.05	.06	.60	—	—	—	—
	0030	A, N, NT, QT	65	35	24	35	131	.30[2]	.70[2]	.05	.06	.60	.50[3]	.50[3]	.25[3]	W .10
	0050	A, N, NT	85	45	16	24	170	.40-.50	.50-.90	.05	.06	.20-.60	—	—	—	—
	0050	QT	100	70	10	15	207	.40-.50	.50-.90	.05	.06	.20-.60	—	—	—	—
	080	A, N, NT, QT	80	40	18	30	163	—	—	.05	.06	—	—	—	—	—
	090	NT, QT	90	60	20	40	187	—	—	.05	.06	—	—	—	—	—
	0105*	QT	105	85	17	35	217	—	—	.05	.06	—	—	—	—	—
	0120*	QT	120	100	14	30	248	—	—	.05	.06	—	—	—	—	—
	0150*	QT	150	125	9	22	311	—	—	.05	.06	—	—	—	—	—
	0175*	QT	175	145	6	12	363	—	—	.05	.06	—	—	—	—	—

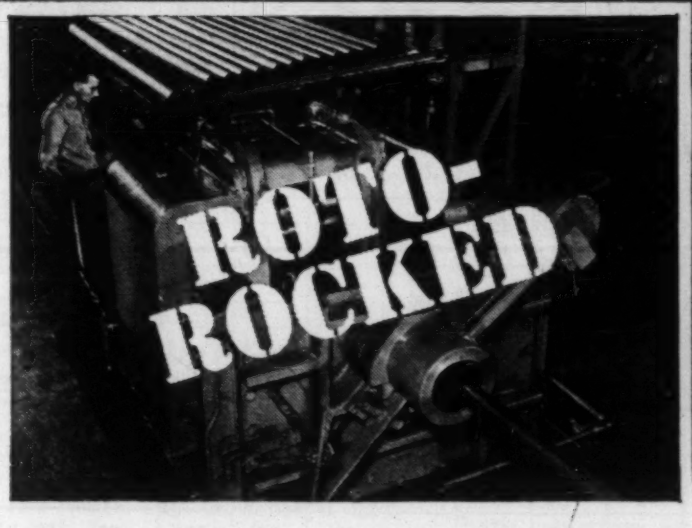
(Continued on page 123)

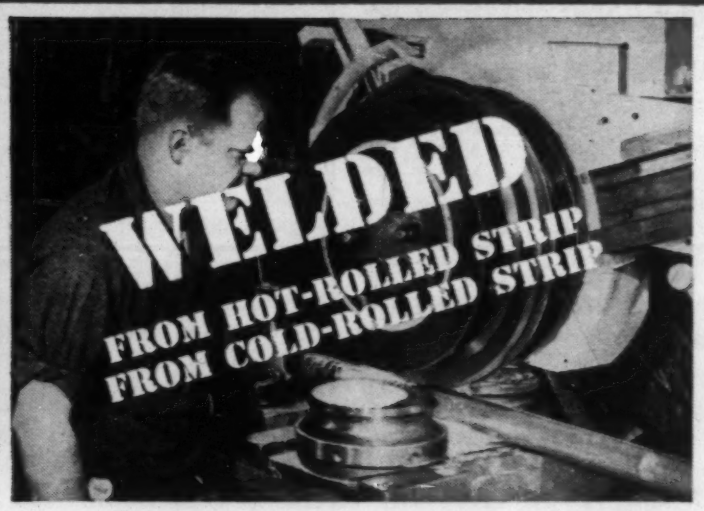
Let's take a

CLOSER LOOK

at TYPES of Tubing







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New Bulletin TB-340 is a compact guide to mechanical tubing possibilities, and well worth writing for.

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TA-1681-M

NUMBER 231 (continued)

STANDARD SPECIFICATIONS FOR STEEL CASTINGS

SPECIFICATION AND HEAT TREATMENT			MECHANICAL PROPERTIES—MINIMUM					CHEMICAL COMPOSITION %—MAXIMUM								
Spec	Class	(#) Heat Treatment	Ten Str, 10^3 Psi	Yld Pt, 10^3 Psi	Elong 2 In, %	Red Area, %	Other Tests	C	Mn	P	S	Si	Cu	Ni	Cr	Other Elements
AAR M 201-47	A	Unann	60	30	22	30	—	—	.85	.05		—	—	—	—	—
	A	A, N	60	30	26	38	—	—	.85	.05	Basic	—	—	—	—	—
	B	A, N	70	38	24	36	—	—	.85	.05	.05	—	—	—	—	—
	C	NT, QT	90	60	22	45	—	—	—	.05	Acid	—	—	—	—	—
	D	QT	105	85	17	35	—	—	—	.05	.06	—	—	—	—	—
	E	QT	120	100	14	30	—	—	—	.05		—	—	—	—	—
AREA	—	A	65	33	24	35	—	.30[2]	.70[2]	.05	.06	.60	—	—	—	—
FEDERAL QQ-S-681b	X	—	—	—	—	—	Bd—deg	.30	1.00	.05	.06	—	—	—	—	—
	0	A	—	—	—	—	—	.45	1.00	.05	.06	—	—	—	—	—
	1	A	60	30	24	35	120	.30[2]	.60[2]	.05	.06	.60	.30	.50[9]	—	.25 each
	2	A, N, NT	65	35	20	30	90	.35[8]	.70[8]	.05	.06	.60	.50	.50[9]	—	.25 each
	3	A	80	40	17	25	—	.50	—	.05	.06	—	—	—	—	—
	4A1	A	75	40	24	35	—	—	—	.05	.06	—	—	—	—	—
	4A2	A	85	53	22	35	—	—	—	.05	.06	—	—	—	—	—
	4B1	N, NT	85	55	22	40	—	—	—	.05	.06	—	—	—	—	—
	4B2	N, NT	90	60	22	45	—	—	—	.05	.06	—	—	—	—	—
	4B3	N, NT	100	65	17	30	—	—	—	.05	.06	—	—	—	—	—
	4C1	QT	90	65	20	45	—	—	—	.05	.06	—	—	—	—	—
	4C2	QT	105	85	15	30	—	—	—	.05	.06	—	—	—	—	—
	4C3	QT	120	100	12	30	—	—	—	.05	.06	—	—	—	—	—
	4C4	QT	150	125	10	25	—	—	—	.05	.06	—	—	—	—	—
MILITARY MIL-S-15083 (SHIPS)	CW		55	27	15	25	—	.30[11]	.70[11]	.07	.06	—	—	—	—	—
	B	A, NT, QT	60	30	24	35	120	.30[11]	.60[11]	.05	.05	.20-.6	.30[10]	.50[9]	.20[11]	Mo .20
	A-70	A, NT, QT	70	35	22	30	—	.35	—	.05	.05	—	—	—	—	—
	A-80	A, NT, QT	80	40	18	30	—	—	—	.05	.05	—	—	—	—	—
	A-90	A, NT, QT	90	55	18	30	—	—	—	.05	.05	—	—	—	—	—
	A-100	A, NT, QT	100	60	15	30	—	—	—	.05	.05	—	—	—	—	—
MILITARY MIL-S-870 (SHIPS)	—	A, NT	65	35	20	30	120	.25[12]	.50-.70[12]	.05	.05	.20-.5	.30[13]	1.00[13]	.20[13,14]	Mo .40-.60
MILITARY MIL-S-15464 (SHIPS)	1	A, NT	70	40	20	35	—	.20	.50-.8	.05	.05	.20-.6	.50[13]	.50[13]	1.0-1.25	Mo .45-.65
	2	A, NT	70	40	20	35	—	.18	.40-.7	.05	.05	.20-.6	.50[13]	.50[13]	2.0-2.75	Mo .90-1.2
A.B.S.	1	A, NT	60	30	24	35	120	—	—	—	—	—	—	—	—	—
	2	A, NT	70	36	22	30	90	—	—	—	—	—	—	—	—	—
	Hull	A, NT	60	30	24	35	120	—	—	—	—	—	—	—	—	—
Lloyds	—	A	58.2-78.4	—	20	—	120	—	—	—	—	—	—	—	—	—

EXPLANATION OF SYMBOLS

Heat Treatment: A—Full Annealed; N—Normalized; T—Tempered; Q—Liquid Quenched.

* Hardenability requirements when specified.

† Hardness tests when specified in contract or order.

[ ] Figures in brackets are expected values only. No test required unless specified in order.

[1] If full anneal specified, 33,000 psi yield required.

[2] For each reduction of 0.01%C below the maximum specified, an increase of 0.04%Mn above the maximum specified will be permitted to a maximum of 1.0%Mn.

[3] Total maximum content of undesirable elements is 1.0%. For each 0.10% below the specified maximum alloy content of 1.0%, an increase of 0.02% in the Cr plus Mo content and 0.06% in the Ni and Cu contents above the specified maximum will be permitted.

[4] Chromium plus molybdenum maximum 0.25%.

[5] Total maximum content of undesirable elements is 1.0%. For each reduction of 0.01% below the specified maximum C content, an increase of 0.04%Mn above the specified maximum will be permitted up to a maximum of 1.1%.

[6] Restrictions on unspecified alloy elements: W 0.10 for all grades; total maximum content of unspecified elements 1.0% for all grades except WC4 and WC5 where total maximum is 0.60%.

[7] Charpy "keyhole" notch impact test required at temperature specified by customer. Test temperature: -25, -50, -75, -100 F, etc.

[8] For each 0.01%C under the maximum, 0.025%Mn above the maximum may be added.

[9] For ordnance castings a maximum of 1.0%Ni is allowed.

[10] For ordnance castings a maximum of 1.5%Ni is allowed.

[11] For each reduction of 0.01%C under the maximum specified, an increase of either 0.04%Mn or 0.04%Cr above the maximum specified will be permitted, but in no case shall the Mn content exceed 1.0% or the Cr content exceed 0.40%.

[12] For each 0.01%C under the maximum, 0.04%Mn above the maximum may be added.

[13] Residual maximum permitted and shall not be added.

[14] For each 0.01%C under the maximum an increase of 0.04%Cr above 0.20% is permitted with maximum at 0.40%Cr.

MISCELLANEOUS REQUIREMENTS

Radiographic Inspection—ASTM: A27, A148, A216, A217, A352; and SAE required when specified. MILITARY: MIL-S-870 required for castings of listed services and other services when specified; MIL-S-15083 all castings shall meet radiographic requirements for BUSHIPS only and for other agencies when specified; MIL-S-15464 all castings shall meet radiographic requirements.

Magnetic Particle Testing—ASTM: A27, A95, A148, A216, A217, A352; and SAE required when specified. ABS required for stern frames. MILITARY: MIL-S-870 required for castings of listed services and other services when specified; MIL-S-15083 all castings shall meet magnetic particle testing requirements for BUSHIPS only and for other agencies when specified; MIL-S-15464 all castings subject to magnetic particle testing.

Hydrostatic Tests—ASTM: A95, A217, A352 required for all castings; A216 required when specified.

Destructive Tests—ASTM: A216, A217, A352 required when specified.

Welding—Major defects over 20% of wall thickness repaired with consent of purchaser by welding with approved process: ASTM: A27, A95, A148, A216, A217, A352; SAE; FEDERAL QQ-S-681b; AAR M201; MILITARY: MIL-S-870, MIL-S-15083, MIL-S-15464.

For Large Injection-Molded Parts . . .

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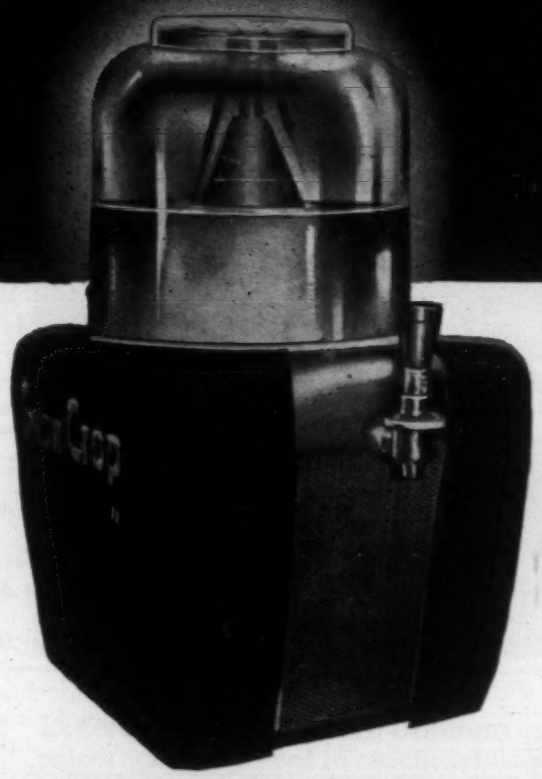

Bowl and cap for Snow Crop dispenser, molded of clear PLEXIGLAS "V". Bowl is 10½" high, has base diameter of 12½", weighs 4.25 pounds. Injection molded on 200 oz. Watson-Stillman machine by A. L. Hyde Company, Grenloch, N. J., for Oiljak Manufacturing Company, Montclair, N. J.

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. . . Second, because the *physical* properties of PLEXIGLAS insure fine appearance and performance in a molded part. Here, the requirements of exceptional clarity, resistance to chemical action, dimensional stability, and strength to withstand sudden impact, were met by use of this Rohm & Haas acrylic plastic molding powder.

Clear and colored PLEXIGLAS is being used for more and more big moldings such as bowls, car visors, diffusers for lighting fixtures, and coin phonograph panels. If *you* want the best results in molding a large part, try PLEXIGLAS . . . for size.

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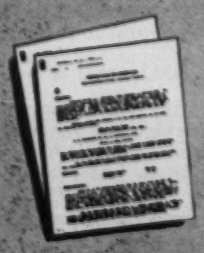
Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*



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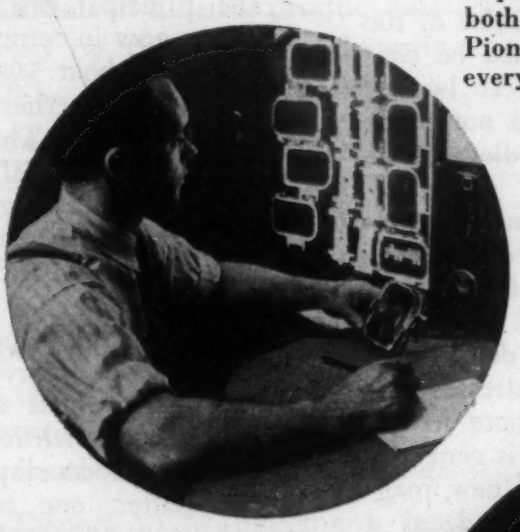

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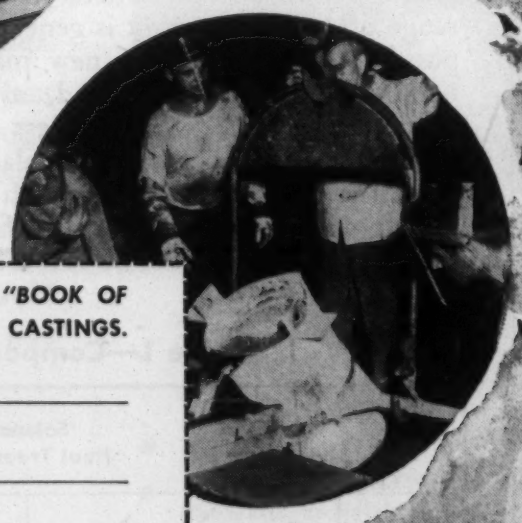

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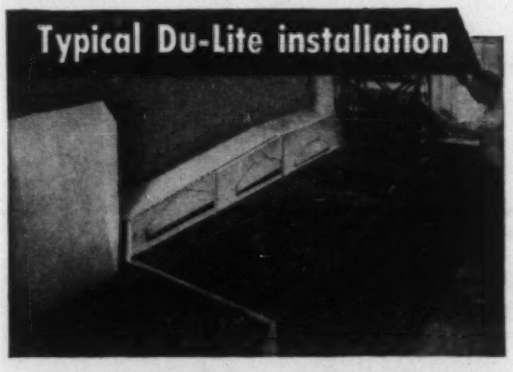

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METAL FINISHING SPECIALISTS

Rare Earth Metals Improve Elevated Temperature Properties of Magnesium Castings

by J. C. McDONALD, Dow Chemical Co.

● THE ADDITION OF rare earth metals to magnesium produces cast alloys having elevated temperature properties markedly superior to those obtainable with the older alloys. By suitable treatment, creep strengths of 8000 psi at 400 F can be developed in the new alloys, compared with 1500 psi for the magnesium-aluminum-zinc type.

Since the magnesium-rare earth alloys are particularly suited for elevated temperature service, it is worthwhile to consider the characteristics which are required of materials for such service. For cast metals, both the mechanical properties at elevated temperatures and the behavior of the alloys in the foundry must be considered. Unless an alloy can be cast at a reasonable cost, it is not likely to be used widely regardless of its properties.

The magnesium-aluminum-zinc alloys, which have been used for many years, can be employed effectively at temperatures up to 400 F. The maximum service temperature depends on the magnitude of the stresses imposed. However, somewhere in the range of 200 to 400 F, it is generally possible to substitute the new magnesium-rare earth alloys and, as a result, reduce the wall-thickness of the part. This is true particularly when the stresses are high enough to require wall thicknesses greater than the minimum which can be cast satisfactorily.

Service experience indicates that creep must be considered in designing components for applications at elevated temperatures. Loads are applied to castings, used in jet engines for example, which persist for several hundred hours, during which the engine is expected to give satisfactory service. Over this period the material gradually deforms until proper functioning of the engine is impossible. Thus, creep strength is one of the major factors in the selection of a material for such service.

The Alloys

The principal cast alloys of the new type now in commercial production contain about 3% rare earths as misch metal, together with 0.25 to 0.7% zirconium. The addition of zirconium is essential to refine the grain in the casting and prevent cracking during freezing. Zirconium also improves the properties of the alloys.

Table 1 gives the compositions and heat treatments of several alloys, the first three of which are in commercial production while the last two are still in the developmental stages. Of the latter, one contains "didymium" (misch metal from which cerium and lanthanum have been removed), the other thorium instead of misch metal.

To obtain the desirable high tem-

(Continued on page 164)

Table 1—Composition and Heat Treatment

Alloy		Solution Heat Treatment		Precipitation Heat Treatment		
% Zr	% Other	Temp, F	Time, Hr	Temp, F	Time, Hr	Designation
0.25	3MM[1]	—	—	400	16	EK30A-T5
		1050	16	400	16	EK30A-T6
0.55	3MM[1]	—	—	400	16	EK31A-T5
		1050	16	400	16	EK31A-T6
0.7	3MM[1]+3Zn	—	—	350	12	EZ33A-T5
0.55	2D1[2]	1000	16	400	16	EK31D-T6
0.7	3Th	1050	2	400	16	JK31A-T6

[1] *MM = Mischmetal; Ce, La, Nd, Pr.*
[2] *D1 = Didymium; mischmetal minus Ce and La.*

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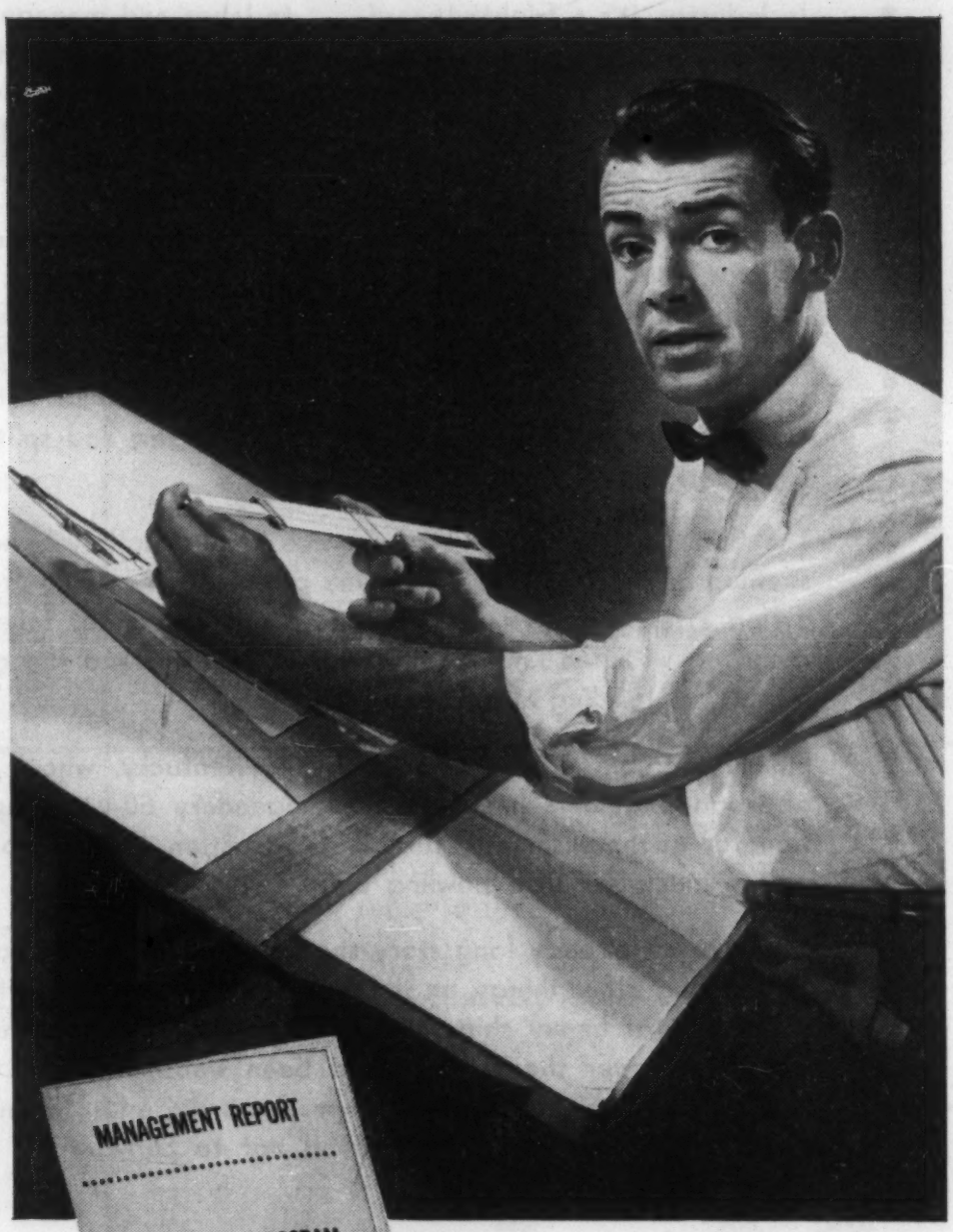

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STRIKE!!

In industry, it's a frightful word . . . to labor and management alike. On the bowling alley, it's the triumphant yell of the scoring team. But . . . to the manufacturer of the bowling pin, it means the shattering impact of the hurtling ball and ricocheting pins.

Since long before Henrik Hudson's famed bowling match in the Catskills, men have bowled against solid wood pins. But recently, the constant search for better pins led to the conclusion that lamination was the answer. Building pins from several pieces of wood, indestructibly bonded, could virtually eliminate the faults of solid-block pins: checking and splitting, chunking, and breaking off at the neck.

The theory was sound but in practice "indestructibly bonded" seemed an impossible hurdle. One proud woodworking organization after another was humbled when it tried but failed to come up with the lamination which could withstand the grueling test of bowling alley use.

Finally Gamble Brothers, in Louisville, Kentucky, whose staff of wood engineers has an almost legendary 50-year reputation for accomplishment, turned its attention to the problem of the much-battered bowling pin.

To make an already long story short, Gamble Brothers, drawing, among other things, on their extensive experience with the laminating of heavy ship timbers and marine parts, came up with the answer the industry had been waiting for. It went into production . . . and still produces superior laminated bowling pins which are guaranteed not to come apart in a glue-line!

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GAMBLE BROTHERS GB GUARANTEED BOND

INCORPORATED

Rare Earth Metals . . . .

continued from page 162

Table 2—Properties

Alloy	T.S. 1000 Psi	Y.S. 1000 Psi	Stress in 100 hr 1000 Psi[a]
70 F			
EK30A-T5[b]	20	15	—
EK30A-T6[b]	23	16	—
EK31A-T5[b]	22	17	—
EK31A-T6[b]	25	19	—
EZ33A-T5[b]	22	16	—
EK31D-T6[b]	38	21	—
JK31A-T6[b]	29	18	—
EK30A-T6[c]	18	13	—
EK31A-T6[c]	22	15	—
EZ33A-T5[c]	20	14	—
400 F			
EK30A-T5[b]	20	12	7.4
EK30A-T6[b]	20	14	7.2
EK31A-T5[b]	20	13	7.7
EK31A-T6[b]	21	16	8.0
EZ33A-T5[b]	21	10	7.5
EK31D-T6[b]	27	20	9.0
JK31A-T6[b]	24	14	11.2
EK30A-T6[c]	16	11	5.0–8.9
EK31A-T6[c]	17	12	6.6–9.8
EZ33A-T5[c]	18	10	5.8–9.0
600 F			
EK30A-T5[b]	10	7	1.6
EK30A-T6[b]	12	7	1.5
EK31A-T5[b]	12	7	1.3
EK31A-T6[b]	13	9	1.5
EZ33A-T5[b]	12	8	1.4
EK31D-T6[b]	15	13	1.3
JK31A-T6[b]	19	13	3.1
EK30A-T6[c]	11	7	1.1–1.8
EK31A-T6[c]	11	7	1.2–1.8
EZ33A-T5[c]	11	7	0.9–1.8

[a] *0.2% total extension*
[b] *Separately cast test bars*
[c] *Bars cut from castings*

perature properties in all of these alloys, heat treatment is necessary. A precipitation heat treatment must be given as a minimum requirement. A preliminary solution heat treatment, optional in several of the alloys, can be used to improve the strength and ductility to some extent but adds to the cost of the alloys. Currently some organizations recommend that EK-31A and EK33A be used in the T5 condition, while others suggest that EK30A and EK31A be used in the T6 condition. EK30A-T5 is not in commercial use.

Properties

The properties of separately cast test bars of these materials are included in Table 2. The strengths of the commercial alloys, regardless of treatment, are quite similar up to 600

(Continued on page 166)

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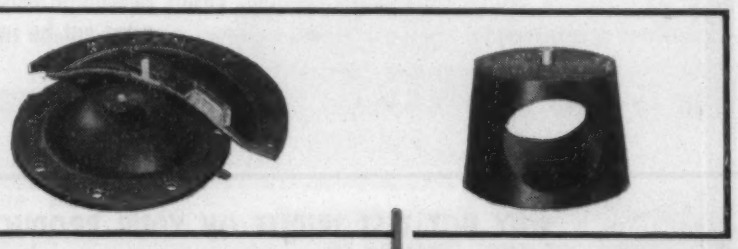

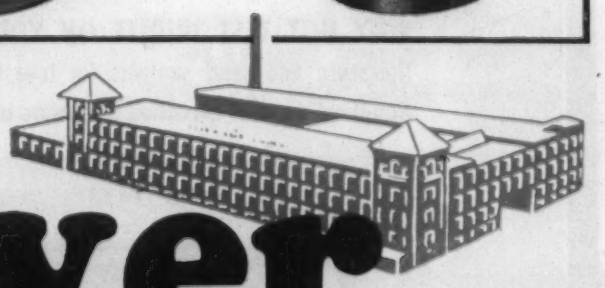

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Rare Earth Metals . . . .

continued from page 164

F, the highest temperature investigated, while the T6 treatment results in some increase in ductility. Of the experimental alloys, that containing "didymium" has properties similar to those of the commercial materials while that containing thorium is far superior at elevated temperatures.

Properties determined on bars cut from castings of the commercial alloys are similar to those obtained on the separately cast test bars. Since these results are in such good agreement, it should be expected that the alloy containing thorium would show superior properties in a commercial casting also.

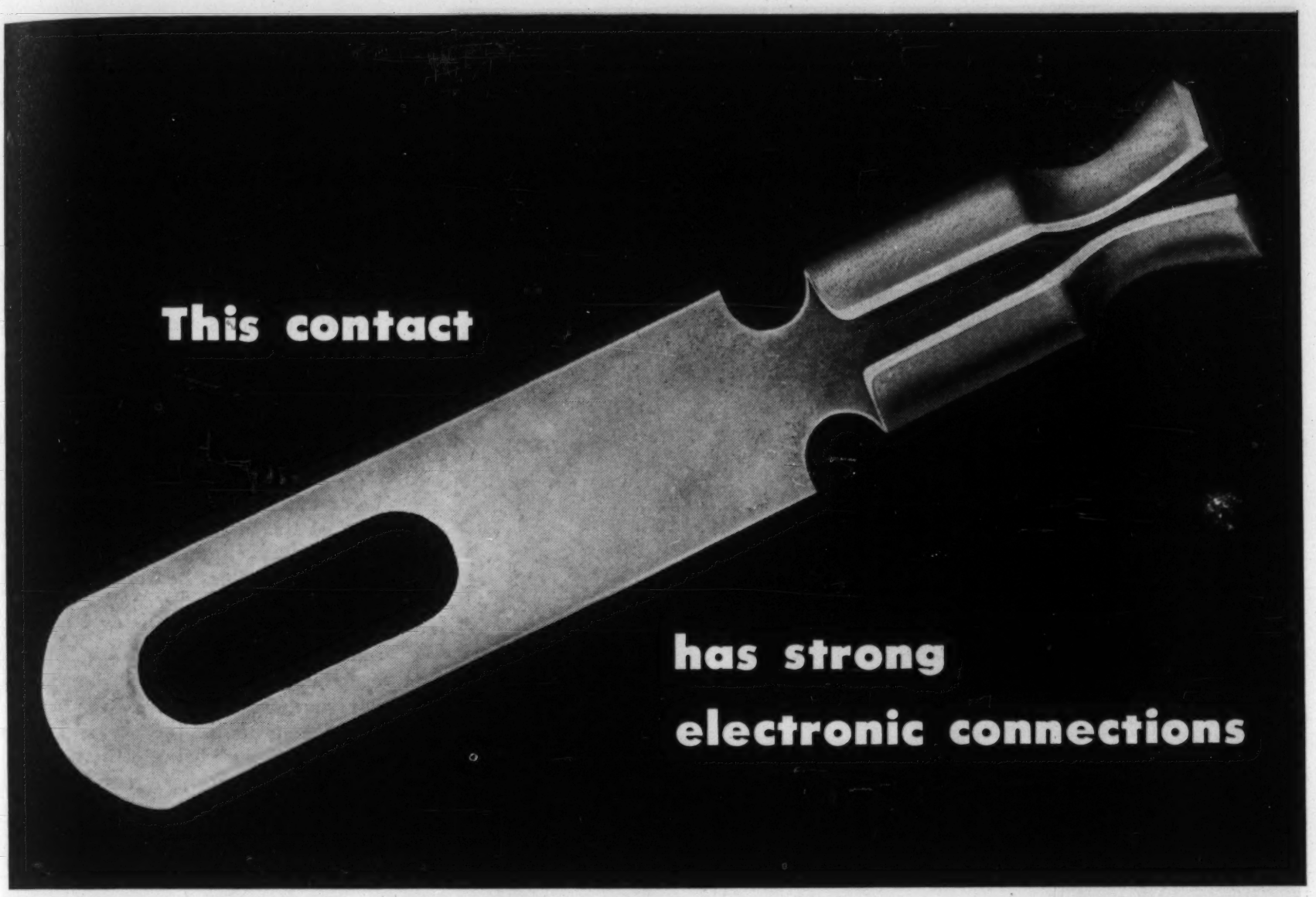
In practice, the commercial alloys behave similarly in the foundry. While offering more difficulties in respect to control of composition and oxidation than the older alloys, these factors can be controlled. The new alloys are easier to produce without internal shrinkage than the older materials, but the factor for shrinkage from pattern dimensions is higher for these alloys than for the magnesium-aluminum-zinc alloy. This makes it difficult to use existing patterns on large castings.

Service experience with corrosion has been satisfactory on all of these alloys to date. Laboratory tests, on corrosion resistance to salt water, rate the commercial alloys as follows: EZ33A, EK30A and EK31A in order of increasing resistance.

All of the materials described have real merit for elevated temperature applications. From the standpoint of overall properties at lowest cost, a satisfactory choice could be made between EK30A-T6 and EK31A-T5. Although EK31A-T6 shows a slight superiority in room temperature properties, it is questionable whether the increase is sufficient to justify the additional cost of high zirconium content and the solution heat treatment required.

Since temperature requirements for airplane service are continually becoming more severe, the primary need for future development is an improvement in creep strength for service above 400 F. The thorium-magnesium alloy shows exceptional strength up to 600 F and promises to be a step forward in the search for new alloys. Developmental work toward commercializing this alloy is progressing.

Adapted from a paper delivered at the Annual Meeting of the Magnesium Association, Nov. 15, 1951.



IT'S MADE OF BERYLCO BERYLLIUM COPPER

The safety of a plane, the effectiveness of a battalion, or the success of a bombing mission may depend on this tiny beryllium copper part, which measures only 5/16 inch in length— one-twelfth the size shown here.

Contacts like this are used in miniature tube sockets for radar, communications and other electronics equipment. Every day thousands of these contacts are stamped out at high speeds on progressive dies.*

The men who design our military equipment are well aware of the old saying "For want of a nail, the shoe was lost" . . . and consequently the battle. The specifications, the load and test requirements, are exacting. Contacts must excel in spring properties, in resistance to both corrosion and relaxation, in electrical conductivity. They must not be subject to vibrational fatigue and must withstand wide variations in temperature. There is one metal which possesses all these essential characteristics to a high degree— Berylco beryllium copper.

Unique properties, such as combination of great strength and electrical conductivity, make this versatile alloy as important in the manufacture of peacetime products as of those for defense. We invite you to take advantage, in your plans for the future, of the technical knowledge acquired by the world's largest producer of beryllium copper. Write or telephone any of the offices listed below.

VALUABLE ENGINEERING INFORMATION on Berylco beryllium copper is contained in a series of technical bulletins, published monthly. To receive your copy regularly, write on your business letterhead.

TOMORROW'S PRODUCTS ARE PLANNED TODAY WITH BERYLCO BERYLLIUM COPPER

Sample material available for testing purposes

*Data supplied by John Volkert Metal Stampings, Inc., Queens Village, L. I., N. Y.

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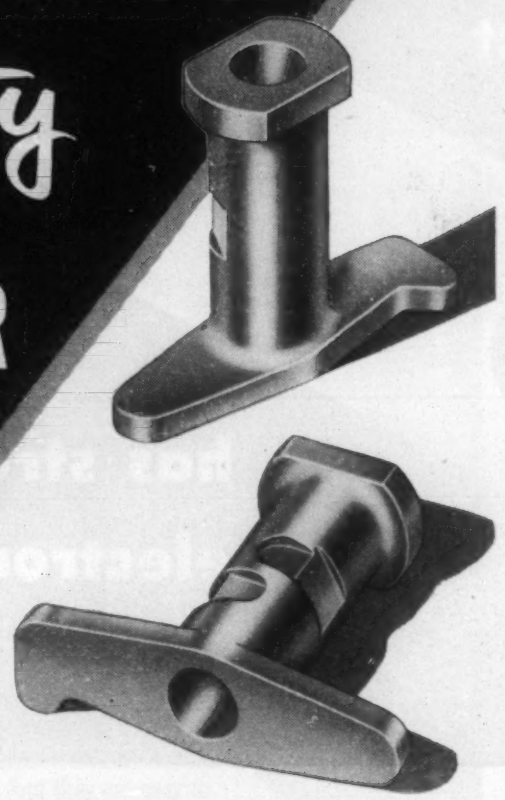

Torque Tube for Gyroscopic Application Investment Cast from S Monel ACTUAL SIZE

Mr. J. B. Lyons* tells us that in the pilot construction stages this torque tube was fabricated in two parts, the flange and the tube and then they were brazed together. Then Hitchiner Precision Investment Castings entered the picture. The resultant saving in turning, profiling, milling, drilling and boring and the elimination of the brazing meant a tremendous saving in cost . . . AND as Mr. Lyons says: "All this has been accomplished without sacrifice of quality."

*Mr. Lyons is Purchasing Agent of the Doelcam Corp., Newton, Mass.

This free folder tells you more about Hitchiner Precision Investment castings . . . send for it today

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News Digest

continued from page 13

The machine has been completely re-engineered to conform with Russian manufacturing practices, machines and materials available. And the Soviet engineers were smart enough not to try improving the American design. They were content with cashing in on the Caterpillar Tractor Co.'s 40 years' of experience behind the Caterpillar D7 tractor.

J. M. Davies, Caterpillar's director of research, made a detailed evaluation of the Stalinetz tractor. He says it's the best engineered of any foreign-made tractors he knows anything about.

Apparently the Russians are not too fussy on looks, for their parts are rough looking in appearance by our standards. But functionally, the parts seem to do their job. Davies also points out that the Russians are up on the latest heat treatment and metallurgical practices. And they have know-how in gear design, too.

When the Russian and Caterpillar tractor engines were tested, their performance was so much alike as to horsepower and torque output and fuel consumption that it was hard to tell them apart.

Right now the Soviet is offering pretty broad engineering services to the export market. It says it can:

1. Design and build automobiles, motorcycles, tractors, highway and road construction machines, tillage equipment, and radio and power stations.

2. Undertake exploratory and research work.

3. Give assistance or consultation in various technical fields.

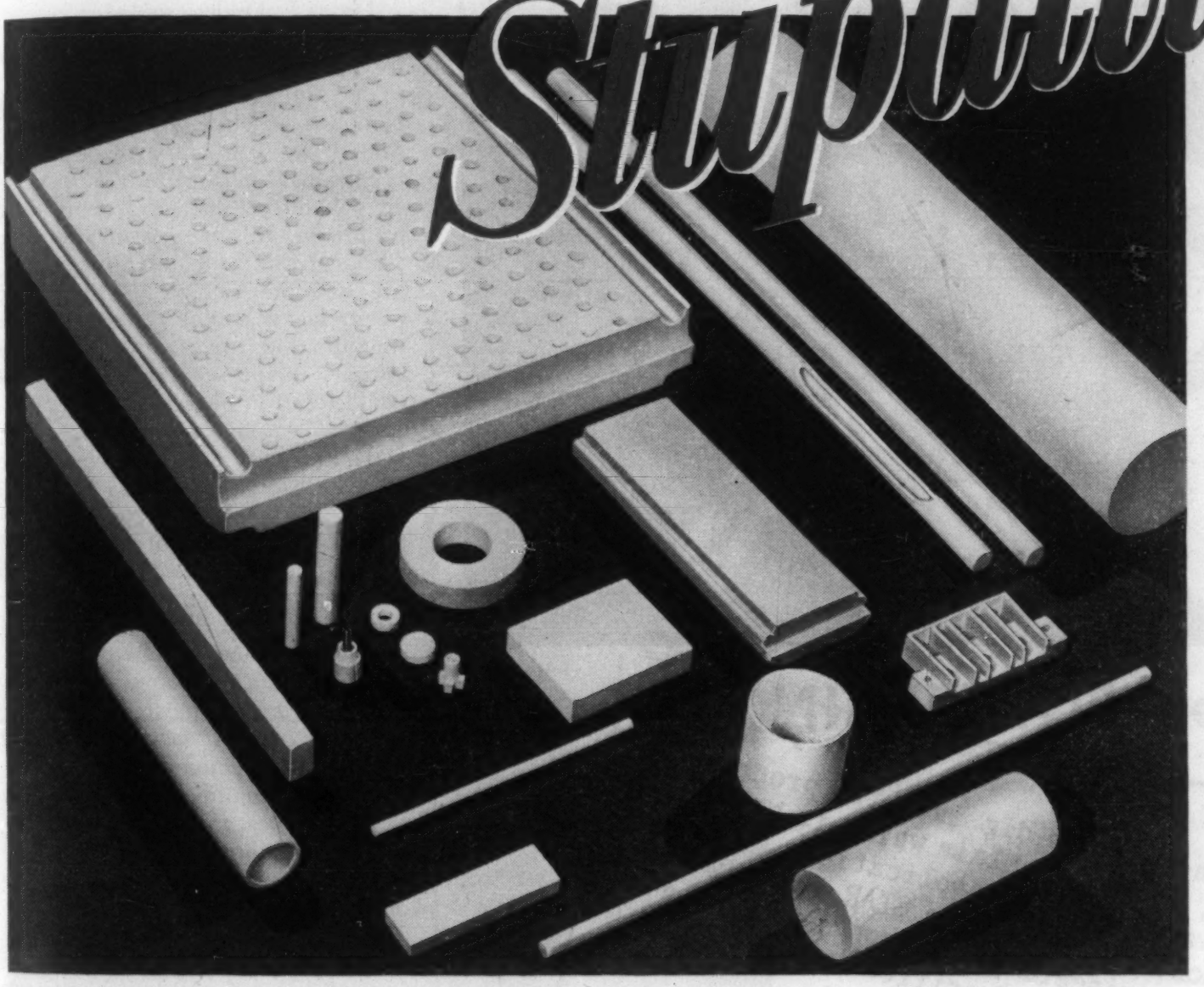
Judging by Russian performance on the Stalinetz tractors, these claims may not be empty ones. The Soviet might easily become our toughest export competitor if it can deliver as advertised.

Engineers Told of Corrosion Problems in Atomic Energy Plants

Corrosion problems in atomic energy plants and some crystal ball gazing in the field of corrosion were the principal topics of discussion at the Northeast Corrosion Conference held in New York City. Under the

Thermal Shock

can't harm parts made of *Stupalith*



Stupalith ceramic parts are made by pressing, extrusion, casting or ramming. A high degree of uniformity and close tolerances are readily maintained.

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Where thermal shock conditions prevail, parts made of STUPALITH will withstand extremely severe service. Stupakoff makes parts ranging from a fraction of an ounce to several pounds in weight, in simple or intricate shapes.

Two principal compositions are ordinarily employed: "zero" expansivity compositions, and non-porous compositions having near-zero expansivities. By varying the ingredients and processing of these compositions, parts having desired expansivity characteristics (negative or low positive) are obtained. For parts requiring a high degree of dimensional accuracy, our production process includes machining or grinding to precision tolerances. Safely used at temperatures up to 2400° F.

Stupakoff will be glad to design and produce in STUPALITH, parts having the resistance to thermal shock or the expansivity your application demands.

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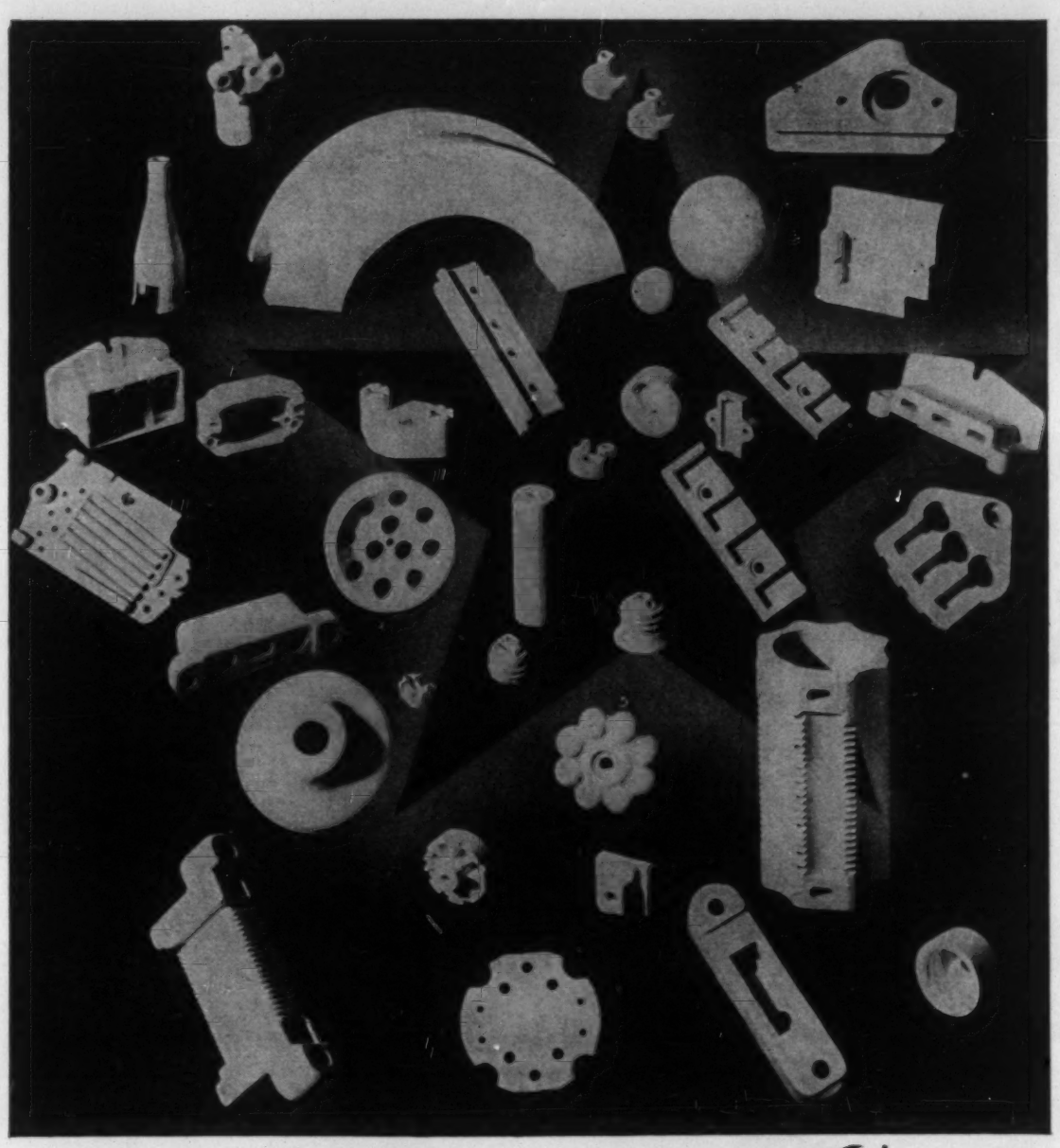

notes on PORCELAIN

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You'll find STAR is set up to give you the kind of service you want - volume production, quick delivery, and steady supply.

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The STAR PORCELAIN COMPANY

MUIRHEAD AND JAY AVES. TRENTON, N. J

News Digest

chairmanship of Kempton H. Roll, the conference was jointly sponsored by the Northeast Region and the Metropolitan New York section of the National Association of Corrosion Engineers.

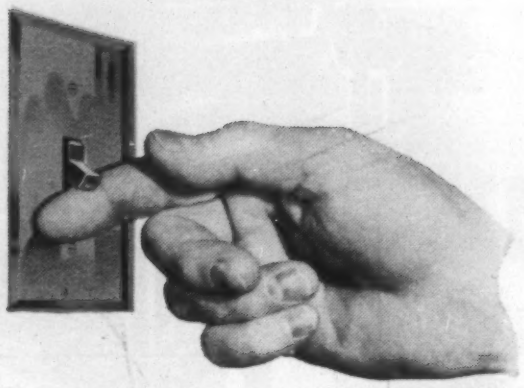
Dr. J. E. Draley, corrosion specialist of the Argonne National Laboratory, stated that the rate of corrosion to be tolerated in atomic energy plants is much less than that permitted in commercial non-nuclear operations. Stringent requirements are, therefore, set up for metallic materials. In the gaseous diffusion plants at Oak Ridge used for separating uranium isotope 235 from the naturally occurring mixture with uranium 238, corrosion of the porous barriers in the separation equipment could result in plugging of the pores.

In a plutonium producing plant, at Hanford, Wash., corrosion of the aluminum cans containing the metal uranium slugs must be strictly controlled. The fission of uranium 235 in the pile produces neutrons which are captured by the nucleus of uranium 238. After a series of nuclear reactions uranium 238 becomes transformed into 239 isotope of plutonium. The heat generated in the pile is removed by water that flows around the aluminum cans. Corrosion of the aluminum would not only reduce the heat transfer properties of the can but might result in can perforation and consequent contamination of the cooling water by the radio-active fission products. The requirement that the can material be free of neutron absorption imposes an additional specification for corrosion resistant metals.

Laboratory investigation of the corrosion resistance of aluminum 2S showed low corrosion rates in aqueous electrolytes in pH range 4.5 to 7.0, temperatures less than 212 F and water velocities up to 20 ft per sec. However, chloride ion in concentration of 2 ppm in this pH range caused pitting. At pH values less than 4.5 and more than 7, the corrosion rate increased rapidly and increased water velocity caused increased corrosion.

As the temperature of the aqueous solution was increased, there was a sharp increase in the corrosion rate of aluminum in the region between 212 F and 302 F. Intergranular attack was observed at 527 F in distilled water whose pH had risen to 8 or higher. The pH value at which

Gloom chaser . . . that works

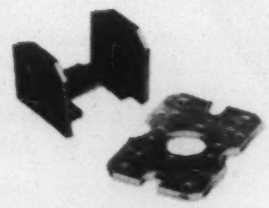


Fair weather or foul, when you flip a light switch you *expect* light. You take it for granted. Actually, like a touchdown in football, the result is the triumph of teamwork in electrical apparatus.

The power company is the captain. The players include the manufacturers of generators, transformers, switch gear, and electrical fixtures. But an *unseen essential* called *Synthane* is present, too.

Synthane is a laminated plastic. It is an excellent electrical insulator. It is also a mechanical material that combines light weight and strength, a chemical-resistant material that machines easily.

Send for the complete Synthane Catalog. Then, if you find Synthane a material you can use, we will be glad to help you with design, sheets, rods, tubes or fabricated parts. Synthane Corporation, 23 River Road, Oaks, Pennsylvania.



Insulator (left) made from Grade X Black Synthane for Square D Company and switch mounting plate made for Cutler-Hammer Inc. of Grade GLCC-M Synthane. Both parts require good electrical characteristics.

Synthane-one of industry's unseen essentials

SYNTHANE

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specializes in . . .

Heat-Resisting
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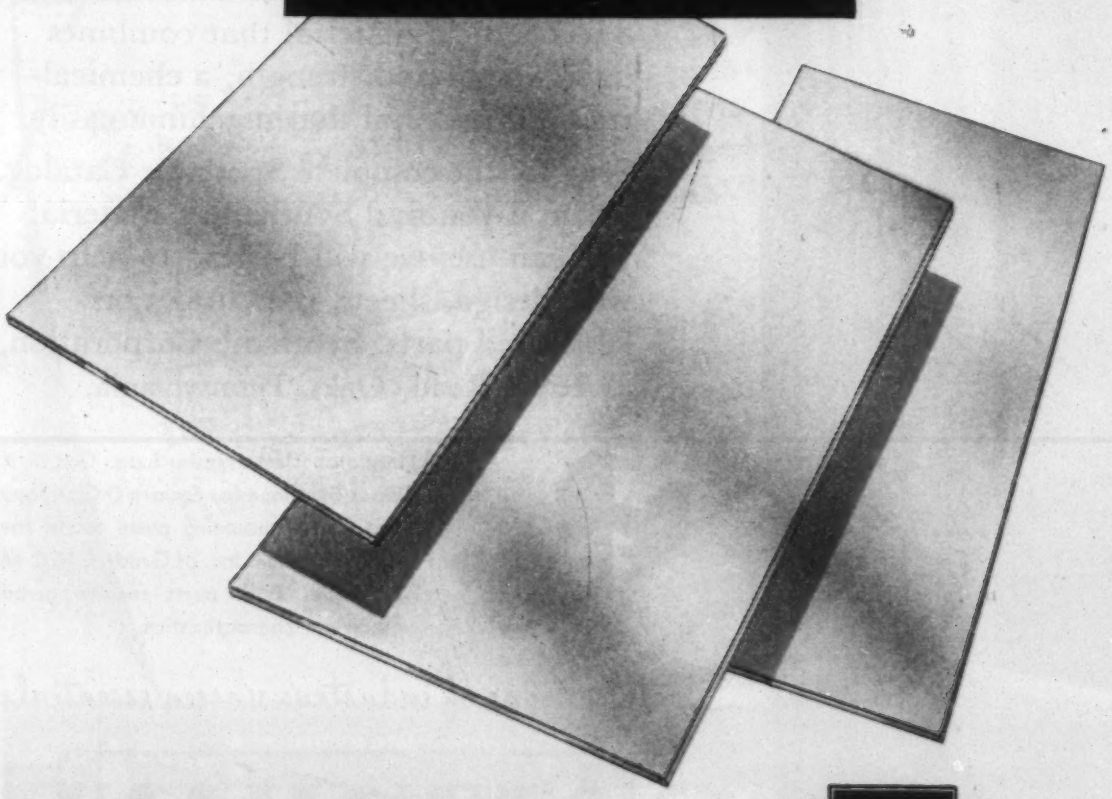

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310 South Michigan Avenue, Chicago 4, Illinois
Plant: New Castle, Indiana

ENGINEERING B-W PRODUCTION

News Digest

aluminum corrosion was minimum varied inversely with the temperature. For example, at 599 F the minimum corrosion rate occurred in a solution with pH of approximately 2.

Among other corrosion problems peculiar to atomic energy operations, mentioned by Dr. Draley, are the handling of corrosive reagents used in the chemical separation of plutonium and uranium, and the difficulty of disposing of radioactive waste products.

The information presented at the meeting represented a portion of an unclassified report being released by the Atomic Energy Commission, containing data on the corrosion resistance of various metals in aqueous solutions at temperatures up to 599 F. Further declassification of information will add considerably to the literature on corrosion.

Dr. H. H. Uhlig, head of the Corrosion Laboratory at MIT and well-known authority on corrosion, reported his ideas of the future in a talk entitled "Corrosion—A Look into the Future." A brief review of Dr. Uhlig's predictions for the future is given as follows:

1. The application of cathodic protection will be extended to protect metals against stress corrosion and fatigue. The protection will be provided by metallic coatings.

2. The achievement of pore-free nickel coatings will permit the use of thinner coatings of this corrosion resistant metal.

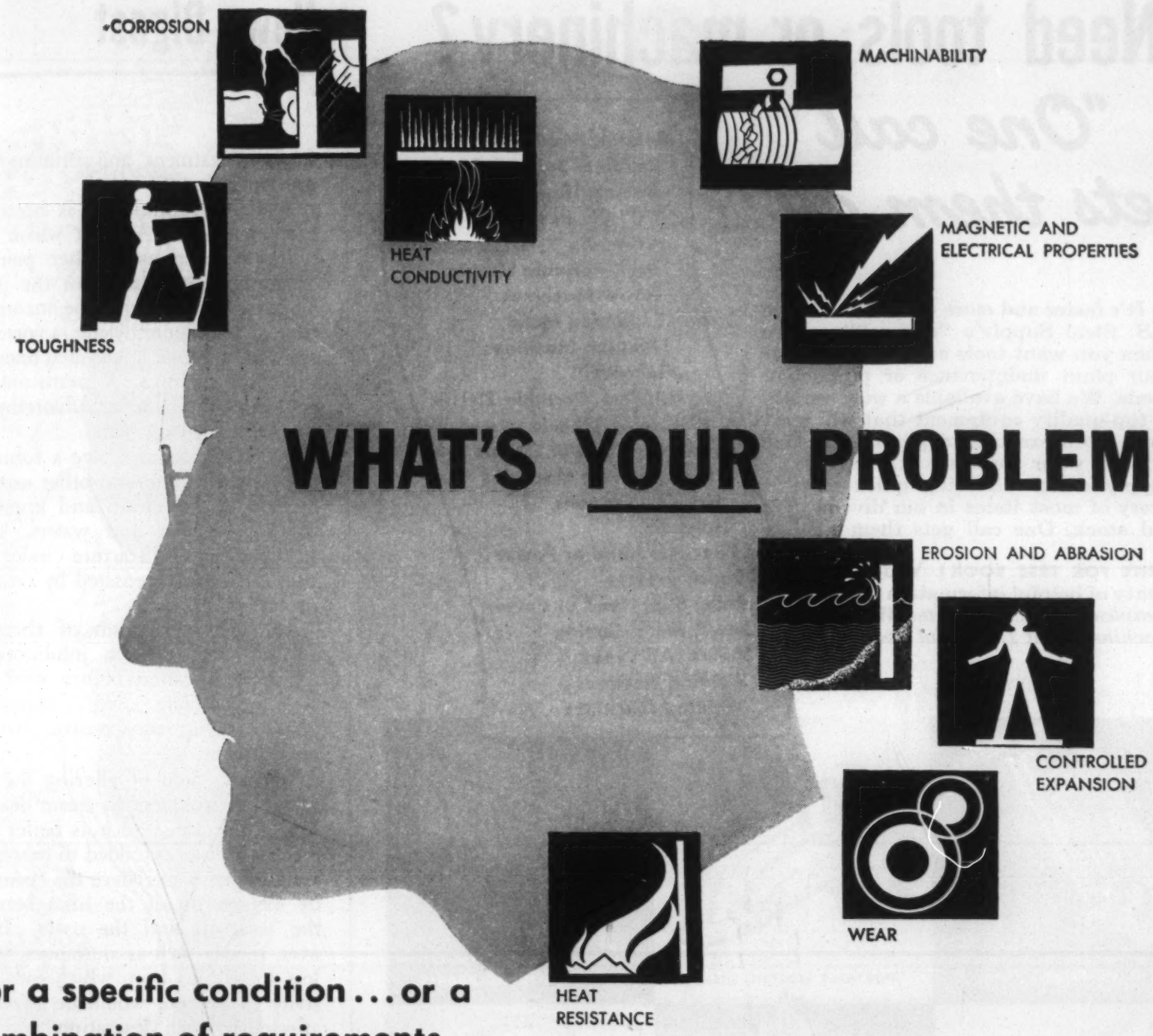
3. A possible substitute for nickel will be bright zinc or zinc alloy coatings protected by a clear lacquer.

4. Nickel-molybdenum (Hastelloy) coatings will be used for plating steel in contact with hydrochloric and sulfuric acids.

5. Titanium, although expensive, will be used for cladding steel in hot water tanks to resist pitting and corrosion cracking in chloride containing waters. Titanium cladding will be used on metals exposed to mine and other acid waters.

6. The sacrificial metals (zinc, aluminum) will continue to be used. Aluminum can be electrodeposited on copper from an organic bath to give resistance to nitric acid. Aluminum coatings on steel will provide resistance against atmospheres containing sulfur compounds.

7. Wash primers (*e.g.* polyvinyl butyral) will come into wider use since they save labor by combining



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NI-RESIST has good resistance to corrosive attacks of *acids, alkalies* and *salts*. In 5% sulfuric acid, for example, NI-RESIST outlasts cast iron 100 to 1.

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NI-RESIST of normal hardness machines like 200 BHN gray iron and is readily weldable.

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NI-RESIST has high specific electrical resistance. (140 micro ohms/cm³)

THERMAL EXPANSION may be controlled from 60% higher than that of plain iron to a low approximating that of Invar.

SEVERAL TYPES OF NI-RESIST are available to meet a variety of industrial demands. Get full information . . . mail coupon now.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of NI-RESIST for many end uses in defense and defense supporting industries. There are authorized foundries, from coast to coast, equipped to quote you on NI-RESIST castings in all common forms and shapes.

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Please send me booklets entitled, "Engineering Properties and Applications of Ni-Resist," and, "Buyers' Guide for Ni-Resist Castings."

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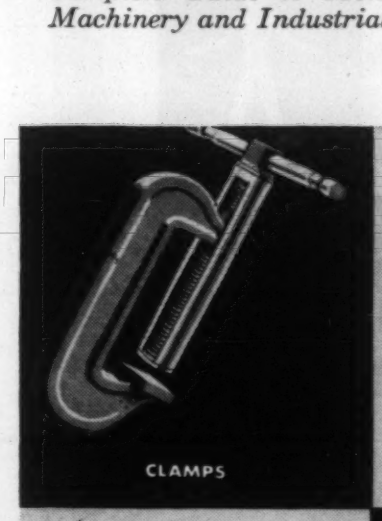
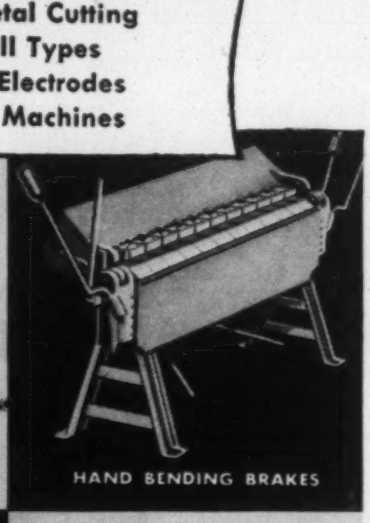
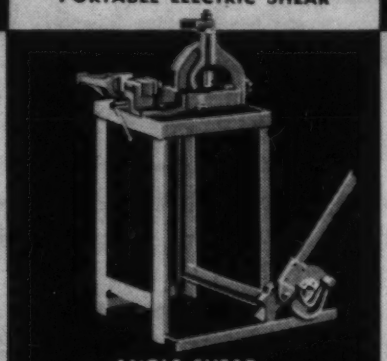
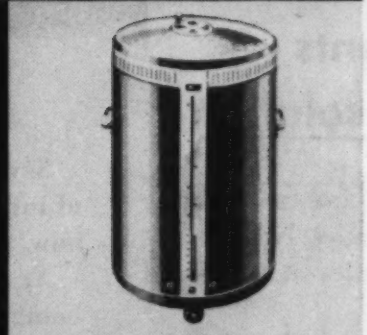

CLAMPS

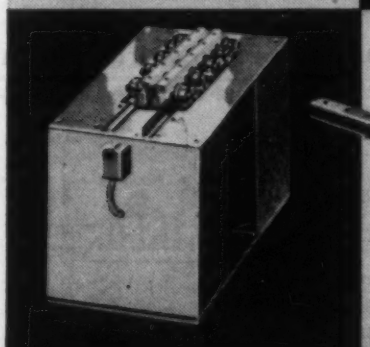
PORTABLE ELECTRIC SHEAR

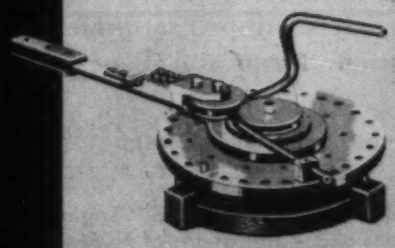

HAND BENDING BRAKES

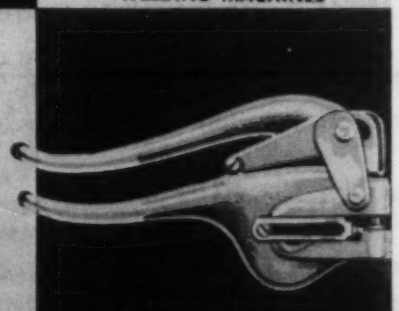
METAL CUTTING BAND SAW


ANGLE SHEAR, NOTCHER AND BENDER


WELDING MACHINES


LOCK FORMING MACHINE


HAND BENDERS


HAND PUNCHES

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UNITED STATES STEEL

News Digest

surface treatment and priming into one operation.

8. Paint formulation is becoming more scientific. A paint which lasts twice as long as another paint is economical at four times the price. This fact will permit the incorporation of tetrafluorethylene, a corrosion resistant material at elevated temperatures into coatings. A means must be found to bond the tetrafluorethylene to the underlying metal.

9. Glass coatings have a future in glass-lined piping and other uses because they are cheap and impermeable to oxygen and water. Their susceptibility to fracture under impact can be compensated by cathodic protection.

10. The mechanism of chromate and nitrate corrosion inhibitors requires clarification before inhibitors will be widely used. Metaphosphates, being inexpensive, have a good future.

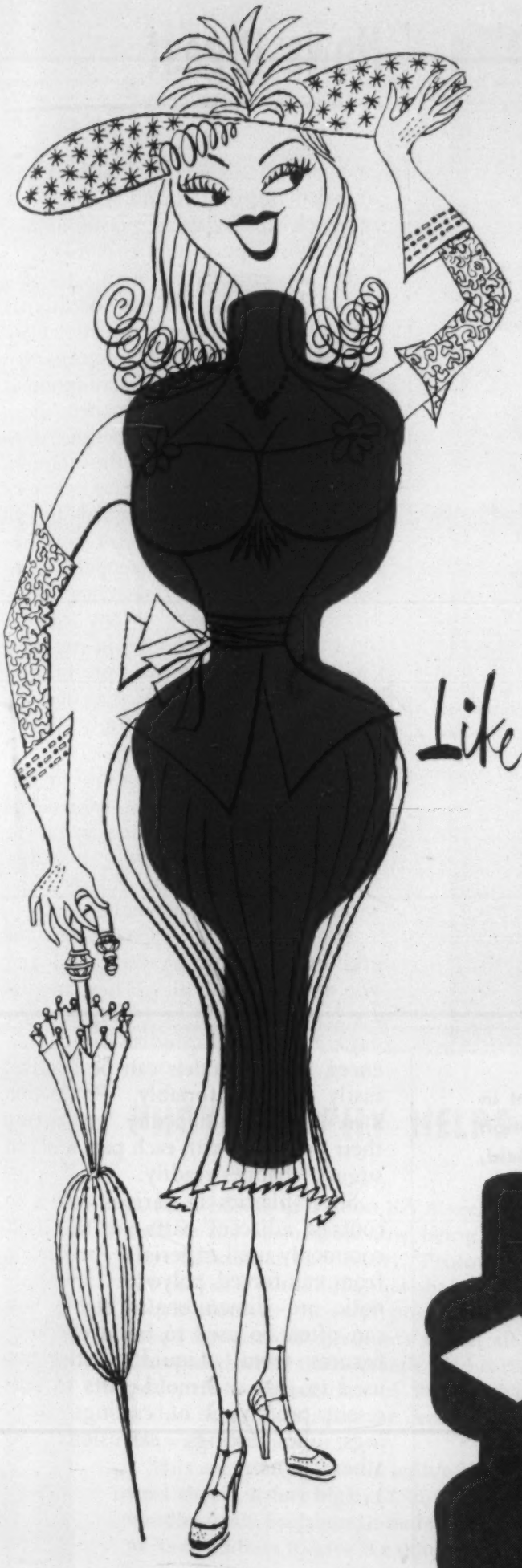
11. The field of altering the corrosion environment by steam deaerating of the water, such as boiler feed waters, will be extended to municipal water systems to reduce the corrosion by oxygen in all the lines between the reservoir and the users. However, metals such as aluminum, stainless steels and iron, which owe passivity to oxygen, would be adversely affected by such deaeration.

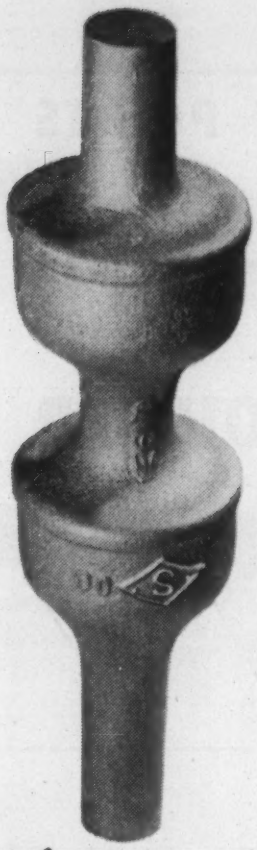
12. In respect to metals and alloys, an increased degree of purification of aluminum and magnesium will result in a 100-fold increase in corrosion resistance. The French are now producing such purified metals. Aluminum will be used to a greater extent in salt water, deactivated of iron and copper salts.

13. In the field of high temperature alloys, an alloy composed of aluminum, chromium, molybdenum and iron will supplement the nickel-chromium alloys.

Plastic Prototypes Successful in Automobile Manufacture

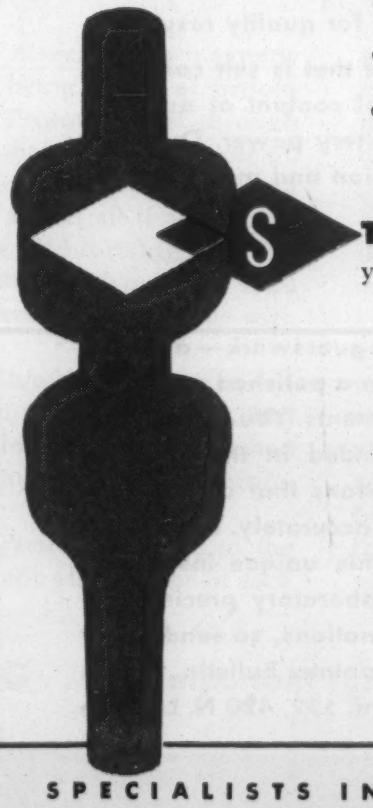
In a paper presented at the summer meeting of the Society of Automotive Engineers, Wallace A. Stanley of the Ford Motor Co. pointed out the success his company has achieved





Like a little glamour in your castings?

Sivyer Castings may not inspire many long, low whistles, but they shape up nicely, nonetheless. Their high dimensional accuracy, clean cored holes, absence of excess metal, and unusually good finish are appreciated by manufacturers with a sharp eye for better casting values. Sivyer "plus" features mean savings for you, too . . . in less handling . . . lower machining time . . . in longer, more dependable casting life. That's why it pays to specify castings carrying the Sivyer Ⓢ



The sign of a "model" casting. The Sivyer Ⓢ is your assurance of the ultimate in safe, dependable steel castings.

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MEASURE THEM ACCURATELY

with the

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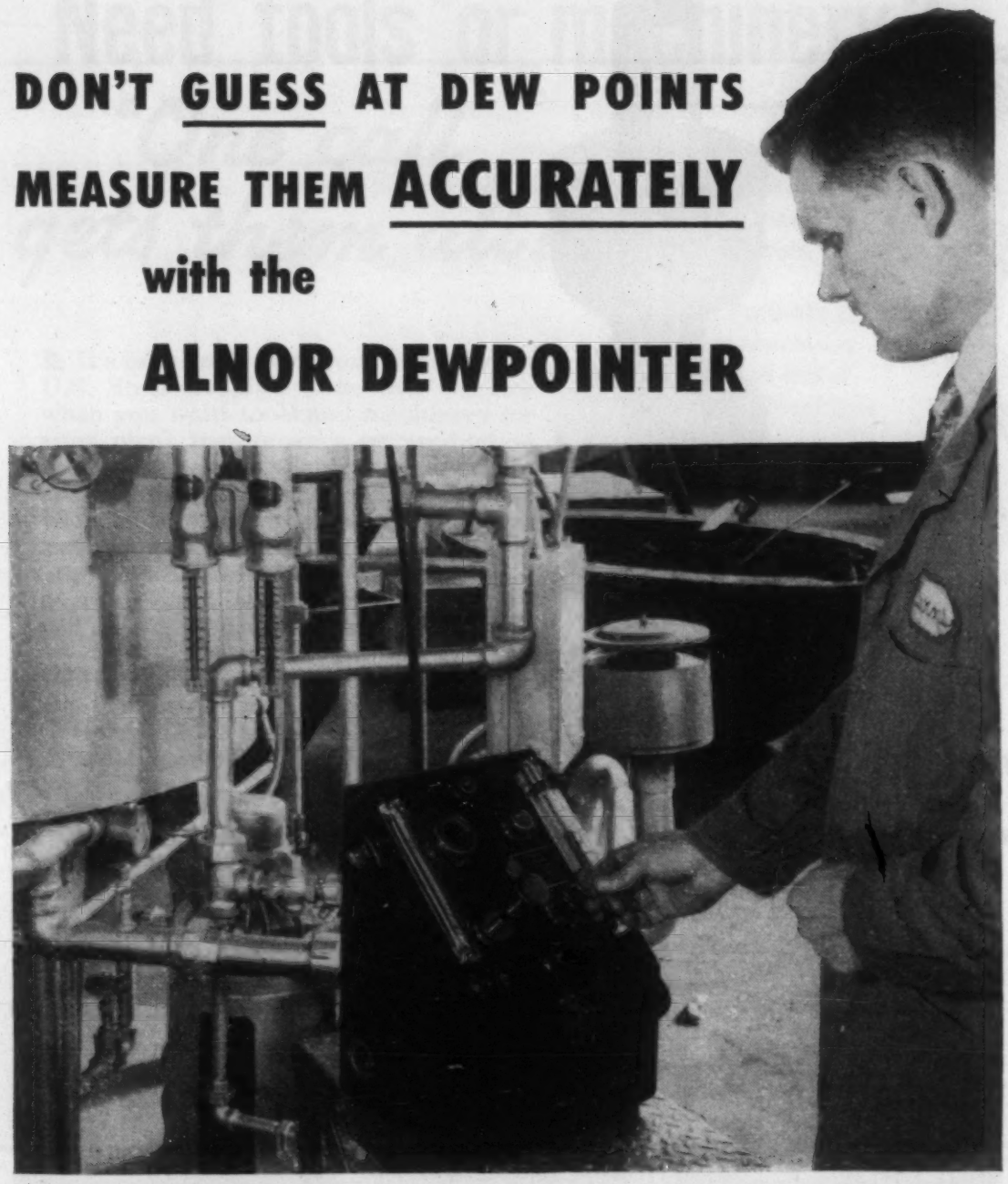
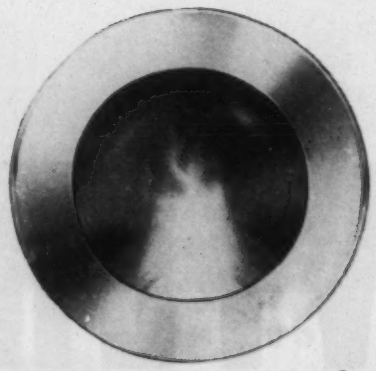


Here's the modern way to quickly and *accurately* read the dew point in controlled atmospheres—the Alnor Dewpointer. Its simple, direct operation assures laboratory accuracy by non-technical personnel . . . in the field, plant, or wherever precision checking is necessary for quality results.

The Dewpointer is the only instrument of its kind that is self contained . . . it is readily portable and requires no external coolant or auxiliary apparatus. Operates on either A.C. or enclosed battery power. Over 600 large industrial concerns rely on Dewpointer precision and many find the instrument pays for itself in savings on CO_2 alone.

Guesswork Eliminated



The Dewpointer eliminates all guesswork—as when trying to read indications on a polished surface in other less accurate instruments. You actually see the dew or fog suspended in the enclosed chamber—under conditions that can be controlled and reproduced accurately. You'll want to know more about this unique instrument that brings portable laboratory precision to your dew point determinations, so send today for your copy of the Dewpointer Bulletin. Illinois Testing Laboratories, Inc., Rm. 522, 420 N. La Salle Street, Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

News Digest

in balancing design and manufacturing problems by using plastic models of proposed parts and assemblies.

In any engineered item, the best theoretical design is not necessarily the easiest to manufacture. Conversely, the most advantageous design from a production standpoint is rarely the best in performance. Both design and production people must make compromises. In the automobile industry, preliminary designs have always been discussed by all departments. It is difficult for production men to visualize parts completely from layouts, sketches or descriptions, however. Many of the most experienced people do not have the time to ponder over preliminary drawings. Perspective sketches are better, but still not entirely acceptable.

Perhaps the best solution to this conference problem is to make actual parts in metal. Such parts would be prohibitively expensive, however, even in the automobile industry, and would take months to make.

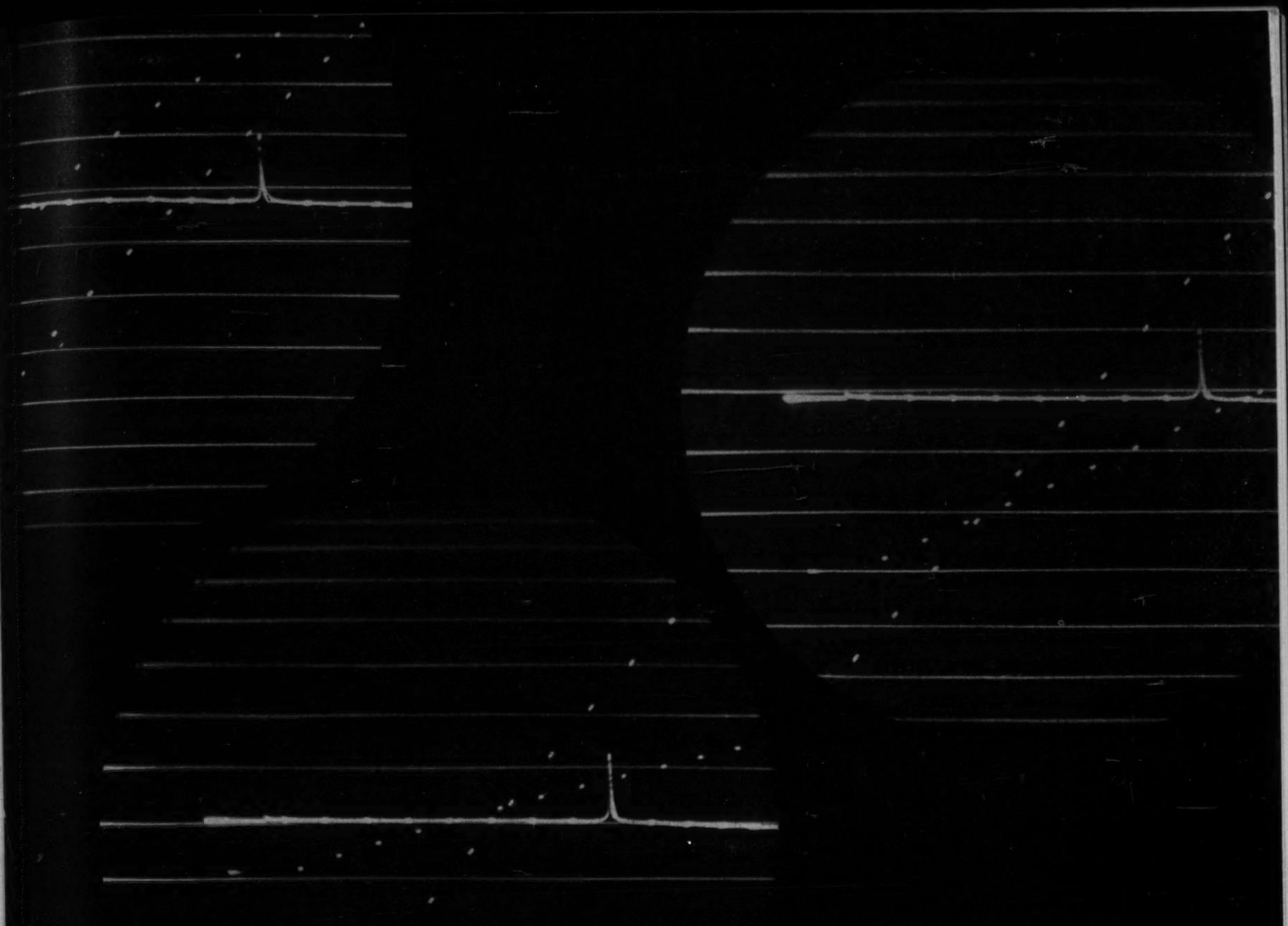
The Ford Motor Co. solves the problem by making scale and full size models of plastics. These models are cheap and can be made in a few days. In design-production conferences, plastic models can be handled easily and comfortably. Production men have no difficulty visualizing their problems with each part and can suggest changes readily.

Sheet plastics in various colors to contrast adjacent parts are the most commonly used materials. Parts made from reinforced polyesters and phenolic are dimensionally stable and can often be used to build checking fixtures from. Liquid plastics are used to cast and mold parts to represent prototypes of castings, forgings, die castings, extrusions and other forms.

Steel Industry Advances Reported at AISI Meeting

The General Meeting of the American Iron and Steel Institute in New York City heard several papers of interest to materials engineers.

Along with the improved properties of sheet steel in the past two or three decades, the price of cold rolled automobile sheets, 20 gage,



PHOTOGRAPHY HELPS A COSMOTRON KEEP PROTONS IN LINE

A peak power of 21,000 KVA creates the magnetic field in the cosmotron now being tested at Brookhaven National Laboratory. Protons whirl through the field of a giant doughnut-shaped magnet, over 60 feet in diameter. At every point of the protons' path along the circular quadrants and at all times during the second while the magnetic field is rising to its top value, the configuration of this field must be held within certain limits, or the protons will collide with the walls and be lost.

This monster magnet is built of laminations of ½" steel sheets, 8 feet high, 12 in a 5.7-ton bundle, 288 bundles in all. Each bundle had to be carefully matched to its neighbors to give the utmost overall uniformity of magnetic parameters.

Photography provided a practical solution to the matching problem. The magnetic phenomena of each block were displayed on a cathode-ray oscillograph and photographed with a Kodak 35 camera. Five months and 8,000 oscillograms later (the shutter didn't fail once), a complete set of photographs like those seen here of the characteristics of each block made it possible to determine the position of each one in the magnet ring, to insure the most satisfactory magnetic field.

Quantitative records—full of detail, quickly made, available for reference whenever needed—are photography's contribution in a great many kinds of scientific and engineering jobs. Kodak makes a large variety of films and papers for them. Drop us a line, and we'll send you a complimentary copy of a new booklet that helps you make the best selection among them. Eastman Kodak Company, Industrial Photographic Division, Rochester 4, N. Y.

PHOTORECORDING . . . an important function of photography

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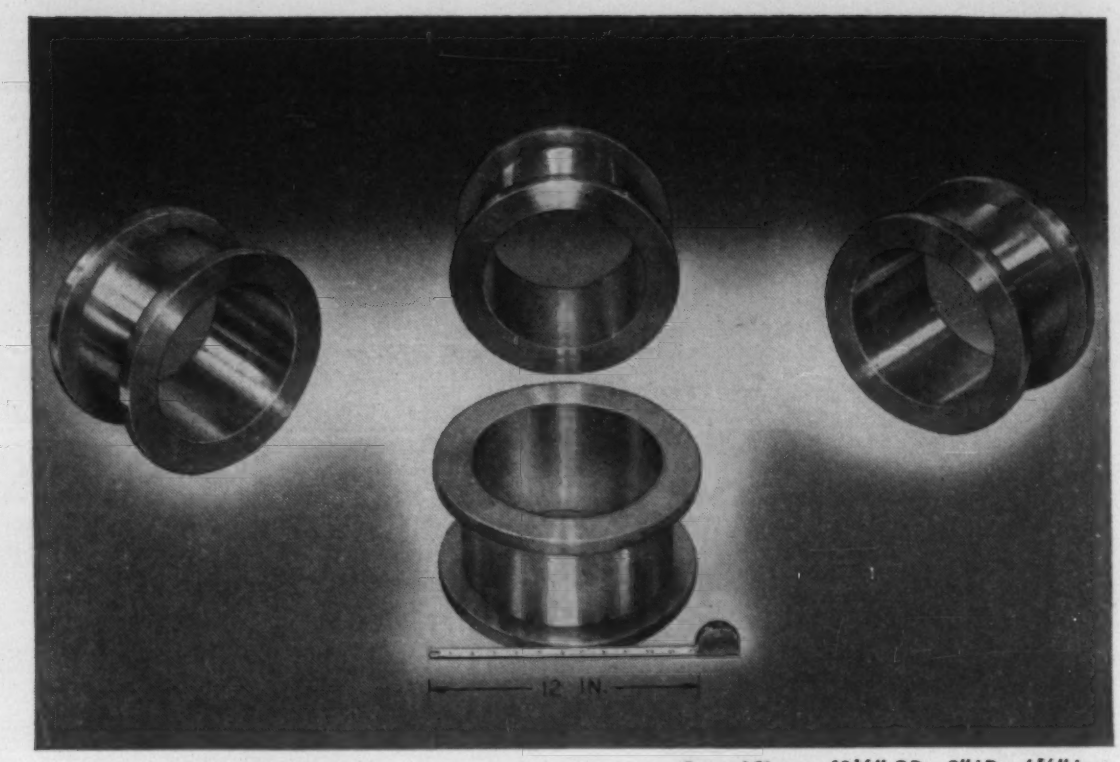

Forged Sleeves: 12¼" OD x 9" ID x 6⅝" long

for complete service

G. O. CARLSON, INC.

forged and rough machined

these stainless steel sleeves

Producing stainless steel forgings is not easy. That is why many plants turn this work over to the experienced personnel of G. O. Carlson, Inc. The forgings illustrated are special sleeves made of Type 302 stainless, formed first as rings and then rough machined in the Carlson machine shop. Products such as these forgings are made at substantial savings because Carlson's technical knowledge, practical skill and specialized equipment combine to do a faster job with less waste of valuable material.

Forgings, heads, diameters, rings, plates and other stainless steel specialties are regularly made by us to meet the most rigid chemical industry standards.

Contact G. O. Carlson, Inc. for your needs in stainless steel.

Stainless Steel is our only business
. . . and we know it

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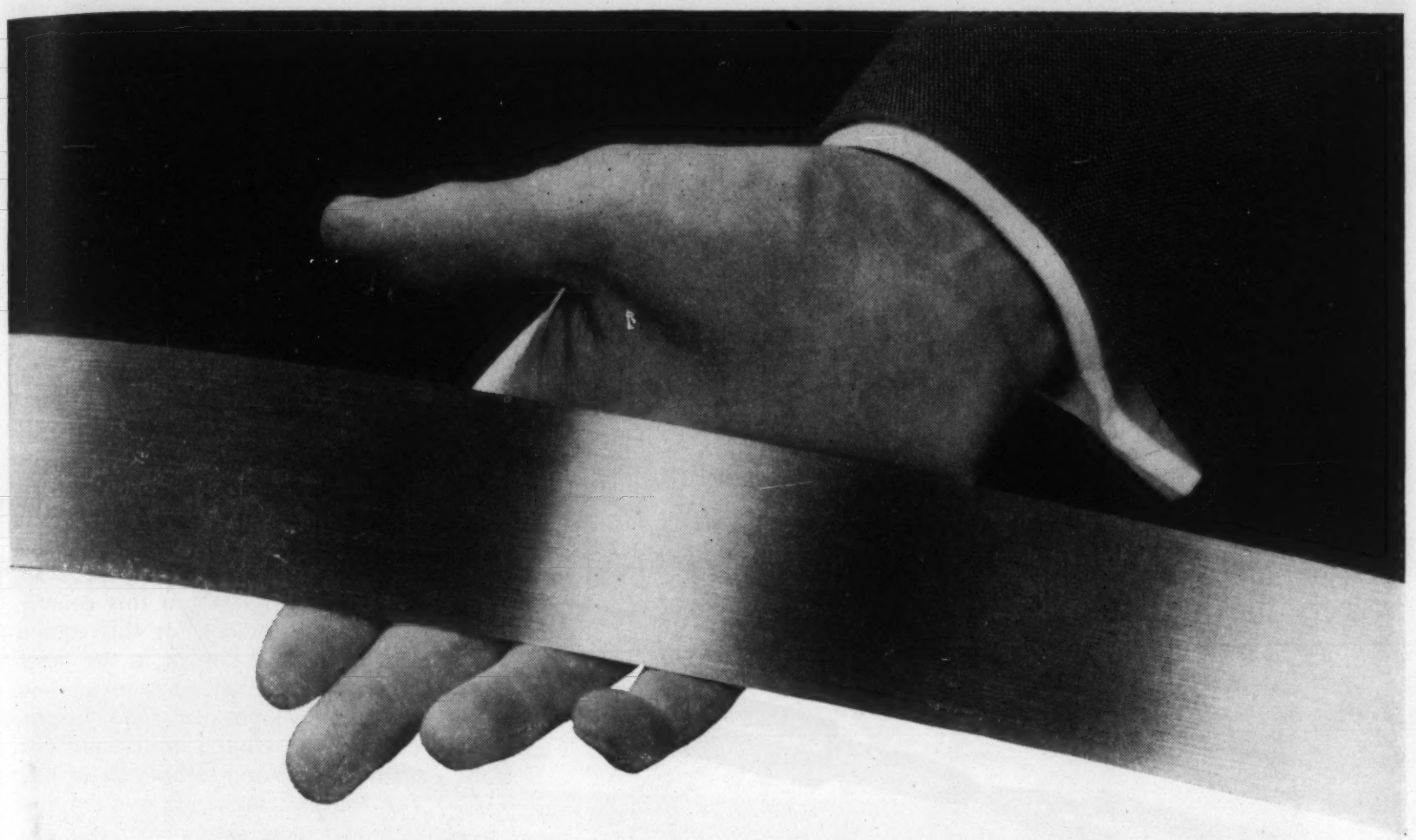
News Digest

has been reduced from $125 to $104 a ton, contrasting with large increases, meanwhile, in steel wages and prices of things made largely of steel, according to Frank H. Fanning, vice president in charge of operations, Armco Steel Corp., Middletown, Ohio.

In a paper titled, "Wide Strip Mills—Evolution or Revolution?" Mr. Fanning described the development of this type of steel mill equipment. The production of wide, hot strip became possible, said the author, as soon as engineers were able to reduce to scientific terms the simple principles practiced as an art by the old time rollers on hand mills. The key to the new success was largely in the slightly concave cross section of certain rolls, together with attention to required temperatures and pressures.

With the new method of production proven, new products of steel and new techniques of fabrication were developed. These developments accounted for the employment of many workers in production and fabrication of sheet steel for uses wholly nonexistent before the appearance of the continuous mill. An example is the one-piece automobile top. Household appliances also came into larger steel use because of the qualities of sheets. As a result, the output of flat rolled steel jumped from 11.6 million tons in 1923 to 39.7 million tons in 1950, rising from 31% of total steel production to 53%. Without the new method of sheet production, the price of 20-gage cold rolled sheets, instead of being $104 a ton for a superior product, would be $275 a ton for the hand mill product, according to computations by the author.

Solid glass, which becomes liquid and acts as a lubricant at high temperatures, is the key factor in the Ugine-Séjournet process of hot extruding steel now being used by some steelmakers and fabricators in the United States, according to Jerome Strauss, vice president, Vanadium Corp. of America. Items such as tubing for hollow turbine blades, which would be difficult or impossible to roll economically, can be readily hot extruded, he claimed. Some kinds of steels and superalloys that can be rolled only with great difficulty can be formed by hot extrusion without trouble. Small orders of special steel shapes may be eco-



How temperamental can a piece of steel be?

● Plenty! Because steel is one of the most *versatile* of all materials, it can play tricks on you . . . can be mighty temperamental, even obstinate. But, properly controlled, it works for you precisely the way you want it to!

For generations, National-Standard's Athenia Steel Division has specialized in the behavior engineering of high carbon steel for the most exacting services. Here, they've learned how to take the fullest *advantage* of steel's versatility. It results in specially engineered, rigidly controlled steels that do a *better* job in all kinds of products from umbrella ribs and pen points to camera springs and piston rings.

Perhaps defense production brings you new problems in the application or behavior of steel. National-Standard and Athenia offer you the kind of engineering and development service that has speeded production and cut costs for many and many a manufacturer.

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ATHENIA STEEL	*Clifton, N. J.*	Flat, High Carbon, Cold Rolled Spring Steel
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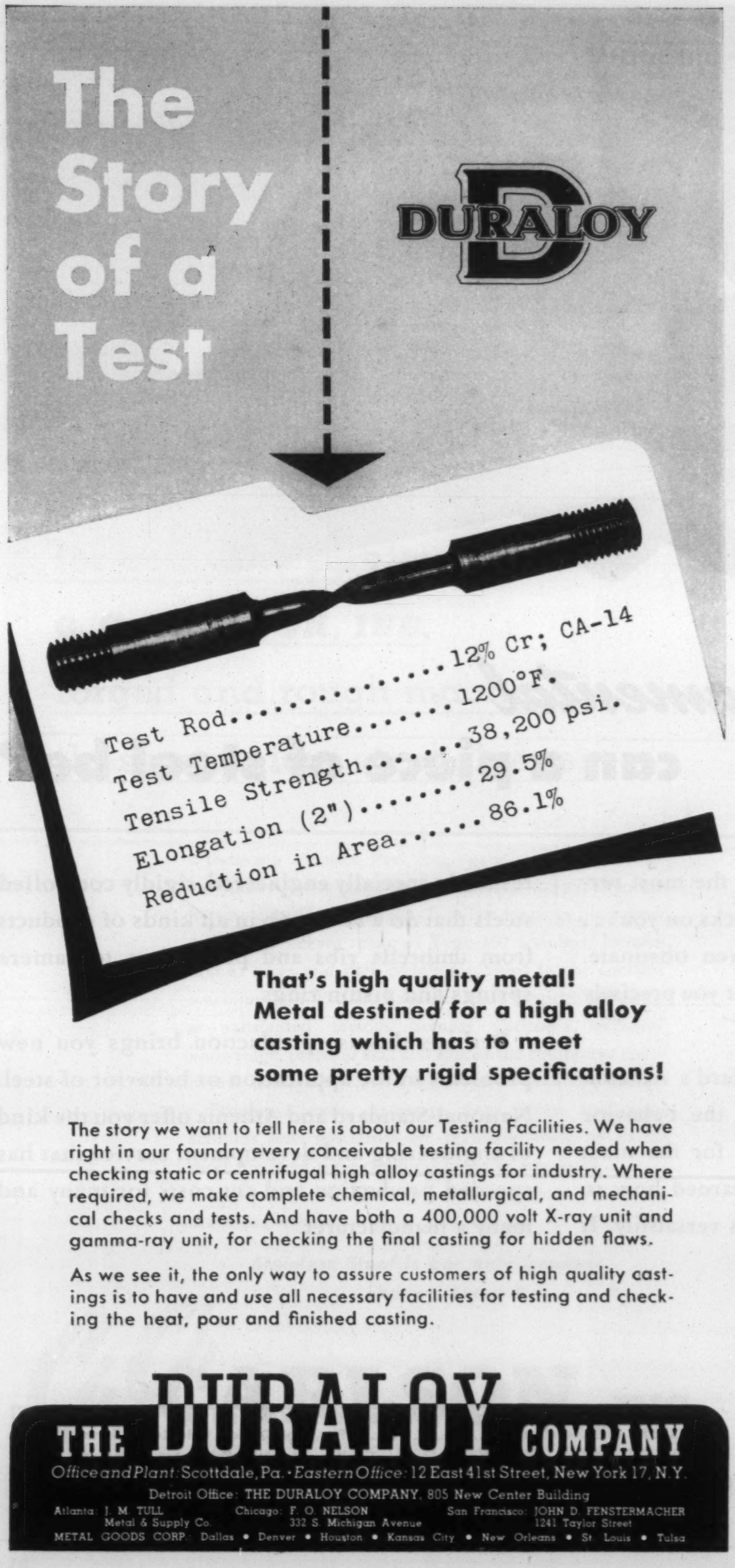
REYNOLDS WIRE	*Dixon, Illinois*	Industrial Wire Cloth
WAGNER LITHO MACHINERY	*Jersey City, N. J.*	Metal Decorating Equipment
WORCESTER WIRE WORKS	*Worcester, Mass.*	Round and Shaped Steel Wire, Small Sizes



That's high quality metal! Metal destined for a high alloy casting which has to meet some pretty rigid specifications!

The story we want to tell here is about our Testing Facilities. We have right in our foundry every conceivable testing facility needed when checking static or centrifugal high alloy castings for industry. Where required, we make complete chemical, metallurgical, and mechanical checks and tests. And have both a 400,000 volt X-ray unit and gamma-ray unit, for checking the final casting for hidden flaws.

As we see it, the only way to assure customers of high quality castings is to have and use all necessary facilities for testing and checking the heat, pour and finished casting.

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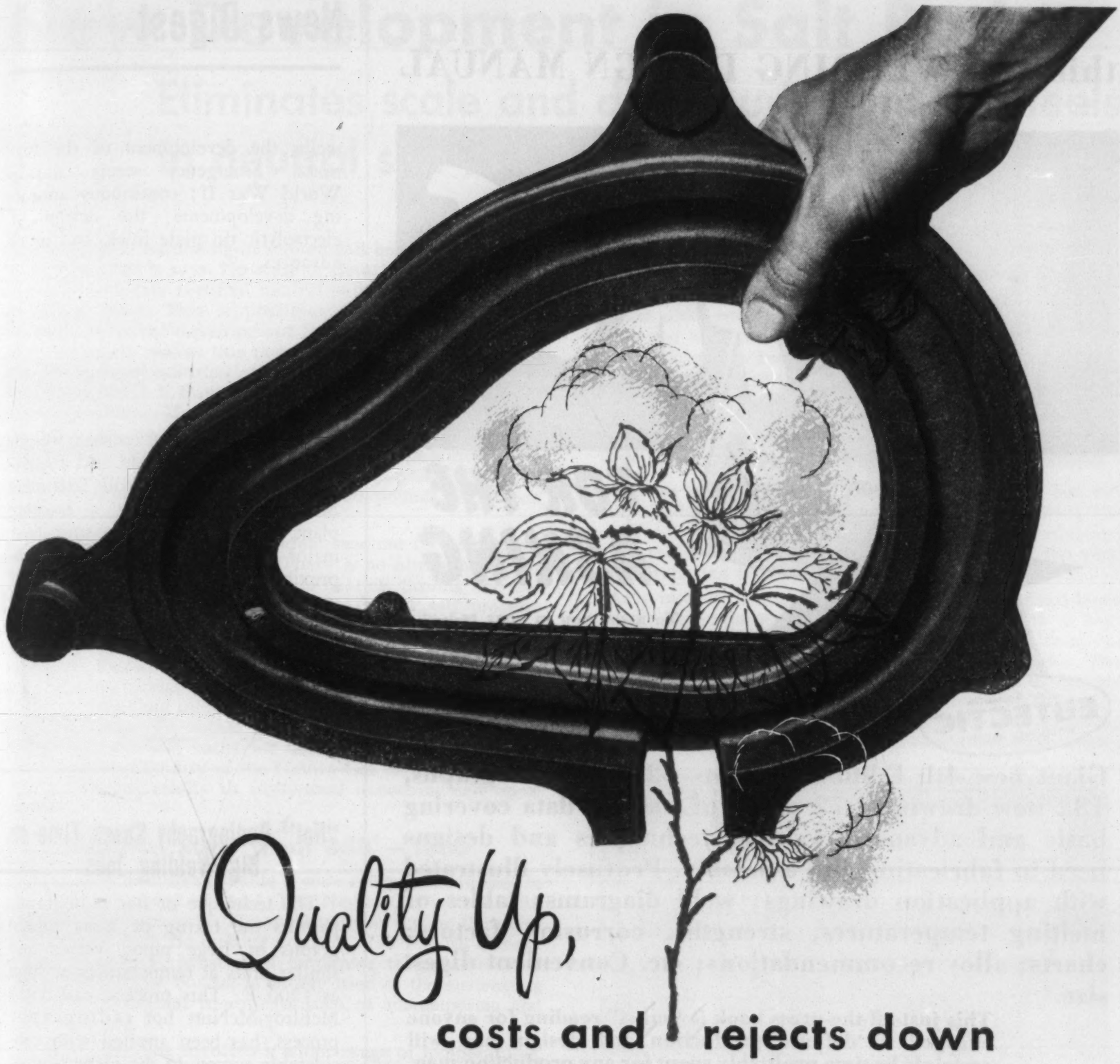
News Digest

nomically hot extruded through a die, where the manufacture of rolls and the necessary adjustments to a rolling mill would be disproportionately expensive.

The use of carbon blocks and bricks in blast furnace linings has lessened the frequency of molten iron or slag breakouts, John J. Hazel, chief ceramic engineer, Republic Steel Corp., told the meeting. Carbon refractories were used in American blast furnaces as early as 1892, but no major installations were made from 1892 to 1945 in this country. Among the reasons for this country lagging behind Europe in the development of carbon refractories were the ample supplies of good flint fire clays in the United States and constantly improving techniques of blast furnace refractories. It was not until new and more severe operating conditions, along with the prolonged peak production period starting with World War II, called for different or higher types of refractories that American furnace experts turned to carbon. The author described the numerous installations of carbon blast furnace refractories that have been made in this country in recent years, discussing their weak and strong points and emphasizing that carbon is not foolproof as a refractory.

A magnificent benefit to this nation would result from any means of imparting to carbon steel the hardenability qualities of the high grade alloy steels, over and above the results now achieved through the use of boron, said E. C. Bain, vice president, United States Rubber Co. Other difficult objectives which may yet be solved, according to Dr. Bain, include developing steel wire with higher strengths than ever before; the development of some new alloying principle which will extend into higher temperatures the high strength of low alloy steels; and finding better ways of inhibiting corrosion. A probable trend is the use of combinations of different materials for maximum effectiveness at minimum cost in the construction of machinery and structures. Dr. Bain also reviewed the many notable accomplishments by steel industry scientists in the 20th Century and pointed to the development of deep drawing steels; the production of tough, heat treated automotive type forgings of medium carbon steel; casing for deep oil



Quality Up, costs and rejects down WITH CRUCIBLE TOOL STEEL CASTINGS

The steel part shown above used to be a production headache. A cam for a cotton picking machine, it was originally flame cut from SAE 8730 boiler plate, machined and heat treated. Other difficult steps included end-milling and finish-grinding the cam track. Rejections were high, because the cam often warped during heat treatment.

The problem was solved by casting the cam in Airkool®, a Crucible air-hardening tool steel. When the customer receives the casting from Crucible, all he has to do is finish it, mill the cam track and heat treat. He doesn't have to finish grind – Airkool is non-deforming when properly hardened and tempered. Machining costs are way down and quality is up, since Airkool resists wear far better than the low alloy steel from which the part used to be made.

Crucible's casting facilities often make it possible to use wear- and abrasion-resisting tool steel for complicated machine parts. We may be able to help you just as we helped the cotton picking machine manufacturer. Get in touch with Crucible today!

CRUCIBLE

52 years of Fine steelmaking

first name in special purpose steels

SAND CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

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WELDING ALLOYS

To assist you in your re-tooling problems . . . or to help you analyze your present welding methods so that you may enjoy maximum speed, efficiency, and economy in many of YOUR production problems . . .

Giant new 4th Edition contains 62 new photographs, 132 new drawings, 72 pages of helpful data covering basic and advanced welding techniques and designs used in fabricating and assembly. Profusely illustrated with application drawings; weld diagrams; tables of melting temperatures, strengths, corrosion factors; charts; alloy recommendations; etc. Convenient digest size.

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SEE . . . The unbelievable savings in metal-joining which can now be yours through the use of "Low Temperature Welding Alloys"® discovered a few years ago and now used in over 78,000 industrial plants throughout America for more efficient metal-working production as well as for salvaging irreplaceable tool and machine parts.

Over 100 different, new, EUTECTIC Low Temperature WELDING ALLOYS® and EUTECTOR® Fluxes are job-engineered for use on ALL metals – cast iron, alloy steels, aluminum, copper and nickel alloys, die castings, overlays, etc., and may be applied with ALL heating methods – torch, arc, furnace, induction heating, etc.

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News Digest

wells, the development of the National Emergency steels during World War II; continuous annealing developments; the design of electrolytic tin plate lines, and other advances.

The world's largest crusher, weighing more than a million and a quarter lb, will be built by Allis-Chalmers Manufacturing Co. for a taconite plant. The crusher will require four major steel castings weighing approximately 700,000 lb. They will vary in weight from 120,000 to 200,000 lb, and will have walls up to 8 in. thick.

"Hot" Radiography Saves Time on Big Welding Jobs

The technique of hot radiography permits the taking of x-ray photographs of large pipes, valves and similar units at temperatures as high as 1200 F. This process, called the McElroy-McNutt hot radiography process, has been applied with considerable success to the inspection of partially completed welds on hot sections of pipe to check for possible welding defects.

Because hot radiography can be accomplished at elevated temperatures, the method eliminates several time-consuming steps necessary for the usual radiographic inspection techniques. Radiography involves taking a picture of a material by placing a sensitized film on one side of the material and a source of x-rays or gamma rays on the opposite side. With the ordinary technique, before the film can be placed on the weld, the pipe section must be cooled down to about 100 F. With certain types of alloys, this cooling must be preceded by post-heating the weld to relieve internal stresses. Because of the lengthy cooling period involved, the usual practice has been to complete the weld before inspecting it.

However, hot radiography, which

New Development in Salt Baths

Eliminates scale and decarburization on steels in neutral salt baths operating up to 2300° F.

NEUTRAL hardening in molten salt baths should mean just what it says. No scale or decarburization is present in a properly rectified neutral salt, regardless of temperatures used. This is possible at 1500°F. and up to 2300°F. A recent development by one of the leading salt bath suppliers makes this possible for the first time without the manual addition of solid deoxidizers. The Neutra-Gas Process (U. S. Patent No. 2474680) is simple, effective, and inexpensive. Merely bubble an inexpensive commercial gas through the molten bath for recommended periods. Neutrality is easily checked chemically or physically. The Neutra-Gas Process is operating at the present time in molten baths weighing less than 100 pounds and those holding several tons of salt.

A truly neutral salt is the ideal medium for heating all steels with no surface effect. There is no atmosphere, and air is excluded while the work is heating. Scaling and decarburization are prevented. A thin film of salt protects parts right up to the quench. With neutral salts operating at 1500°-1600°F., Neutra-Gas is used for just a few minutes per shift. Sludging is practically eliminated; economies result because sludging removes good usable salt. The bath remains very fluid allowing rapid and uniform heating with less distortion. To obtain all the advantages of salt bath hardening, use salt baths for both heating and quenching The improved fluidity of the Neutra-Gas controlled neutral salt assists materially in isothermal quenching salt operations.

Neutral Salts from 850° — 1850°

Various salt mixtures provide a wide range of usefulness in the heat treatment of steel. The Neutra-Gas is used with chloride mixtures only. The most popular type is Park Nu-Sal Neutral Salt. Its melting point is 1230°F. with a range of 1300°-1600°F. Most steel hardening temperatures fall within this range. Nu-Sal is widely used as the austenizing bath for isothermal treatments such as austempering and martempering.

Cycle annealing involves a wider range of temperatures. Park K-3 Neutral Salt melts at 1020°F. and is usable past 1700°; periodic use up to 1850° is permitted if proper rectification is made with Neutra-Gas.

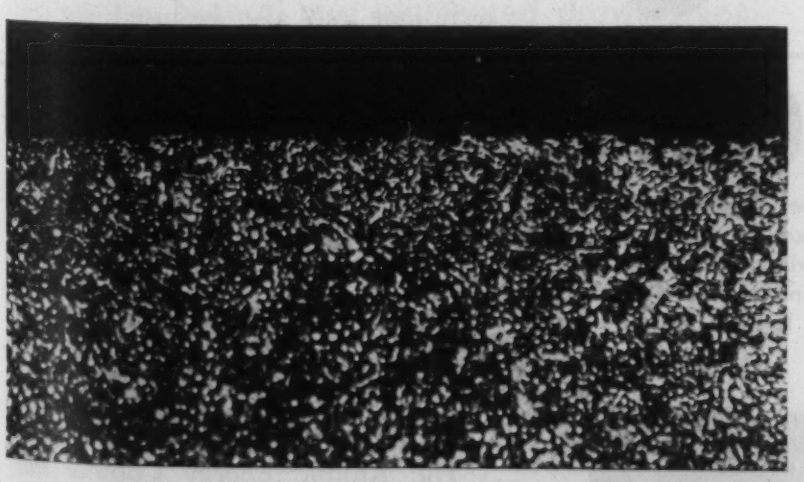
Low melting salts are available for special purposes. Park's #800 Neutral Salt (melting point 850°F.) and Park #900 Salt (melting point 920°) are used for tempering, high speed steel quenching, and have a range up to 1700°F.

Baths operating consistently at 1700° to 1900°F. usually operate with less fuming and volatilization if their melting points and top operating temperatures are slightly higher. Park K-17, with a range up to 1900°F., also has a reasonably low melting point of 1175°F. Economy is indicated here as the temperature of an idle furnace may be kept at 1250°-1300° with very low power costs.

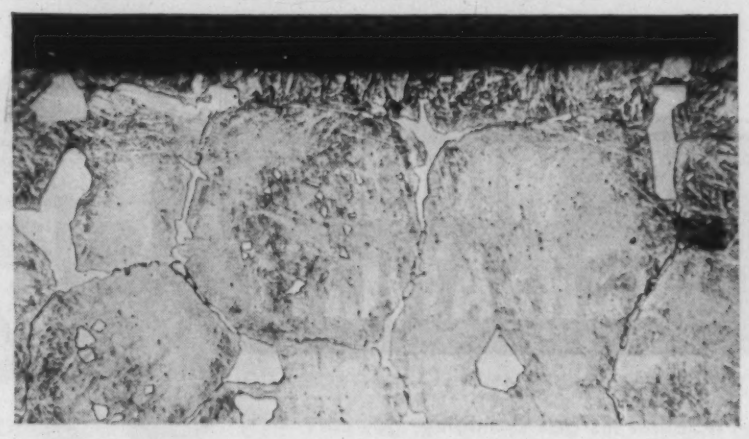
No Decarb on Moly High Speed Steels

Wider use of molybdenum high speed tool steels has virtually made the use of salt baths mandatory. During the last War it was salt baths which made possible the adoption of the molybdenum high speed steels in place of the very critical tungsten types.

As in most instances, the increased use of a method leads to rapid improvements. The improved rectification of high heat salt baths operating from 2200°-2300°F. is a development of the Park Chemical Company laboratories. The Neutra-Gas Process was adapted to the higher temperature applications in order to reduce the oxides of the chloride salts. Metallic oxides are reduced by graphite rods immersed in the salt. Costly and laborious sludging has been nearly eliminated and electrode life increased. Size loss of tools is held to a minimum. It is possible to harden unground or finished tools. Scaling, decarb, oxidation, pitting and other surface defects are automatically avoided. Distortion is negligible. Immersion in salt seals out all atmosphere. Salt film protects work right through the quench. For pieces large or small, temperature is even and constant.



(X 500) Microphotograph of the edge structure on SAE 1095 steel treated for 60 minutes at 1450°F. in a commercial installation of Park Nu-Sal kept neutral with the Neutra-Gas process. (Sample quenched in caustic solution and tempered in No. 800 Neutral Salt at 1200°F.)

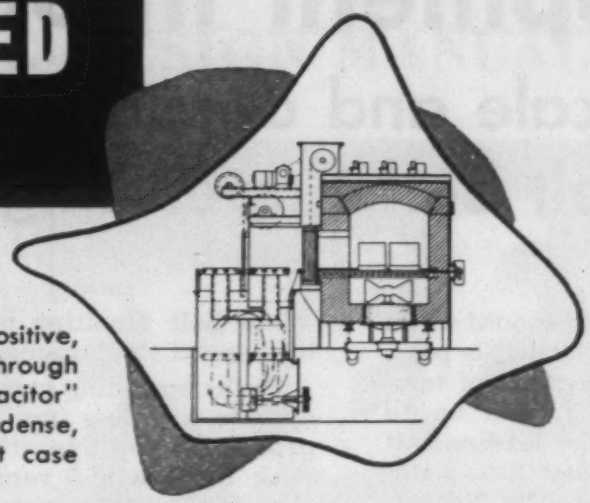


X500—(Reduced in Printing) Edge structure of high speed steel after several hours in a Park No. 175 Hi-Heat salt bath.

Process detail is preheat at 1550°F. in Park No. 117 Preheat Salt, high heat at 2200°-2350°F. in Park High Heat No. 175-S with Neutra-Gas. Quench in either No. 900 Neutral Salt, or in No. 100 Quench Salt which contains a small amount of cyanide. Tempering in salt completes the cycle, free from any deleterious effect caused by contact with the atmosphere.

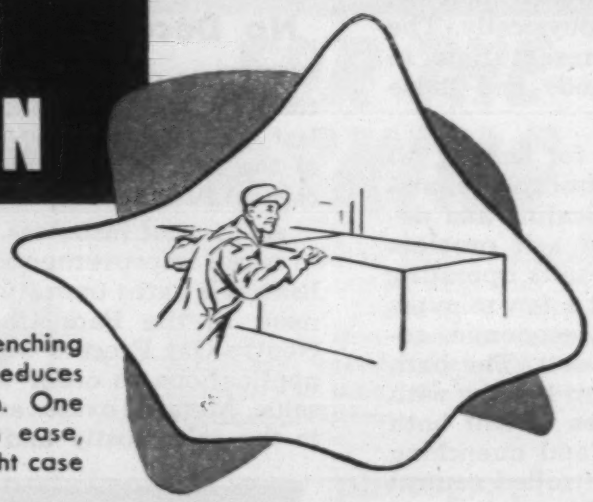
Park's salt baths, and the knowledge of how to make them do a better job for you, can effect economies in your heat treat department. Write, telling us in detail your application, and we will send you the technical bulletin that covers your particular operation. There is a Park field engineer to assist you, backed by a technical staff and 40 years of Park Chemical Co. service to the heat treating industry. Park Chemical Company, 8079 Military Ave., Detroit 4, Michigan.

UNSURPASSED QUALITY



Combines the operating economies of large continuous furnaces with the flexibility of batch-type equipment. Positive, directed flow of furnace atmosphere through load, combined with the "heat capacitor" assures rapid, uniform heating on dense, bulk-loaded parts and even on light case work.

GREATER PRODUCTION



The Dow Furnace has established production records in plants throughout the country. Forced, uniform quenching from atmosphere gives full hardness, reduces distortion, eliminates decarburization. One man can operate two furnaces with ease, producing as much as 1500-lbs. of light case work per hour.

WIDER VERSATILITY

Whether it's gas cyaniding, gas carburizing, clean hardening or carbon restoration work, the Dow Furnace is capable of processing a variety of parts having a wide range of heat treatments. To demonstrate the close tolerances of heat treatments, send us samples of your own parts for processing.

AT LOWER COSTS

Reductions in direct labor, material handling, machining and cleaning costs, coupled with improved quality, have resulted in savings amortizing the original cost of the Dow Furnace in a few months. Gas cyanides for ¼ to ⅓ the cost of liquid cyaniding.

THE DOW FURNACE COMPANY

FIRST
WITH MECHANIZED BATCH-TYPE
CONTROLLED ATMOSPHERE FURNACES

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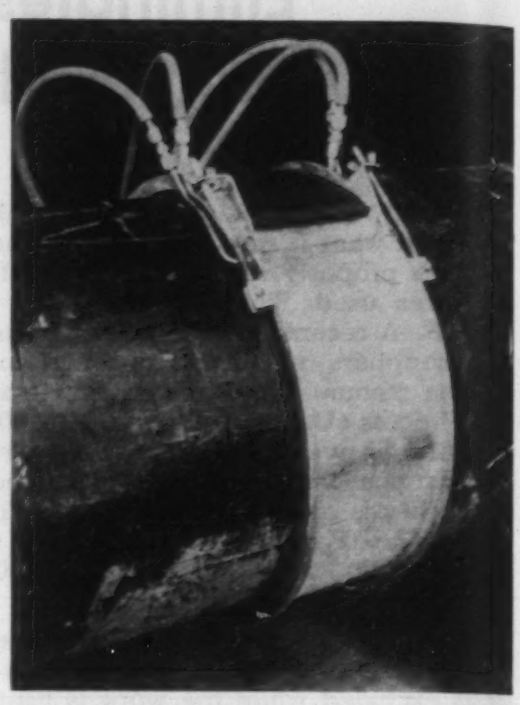


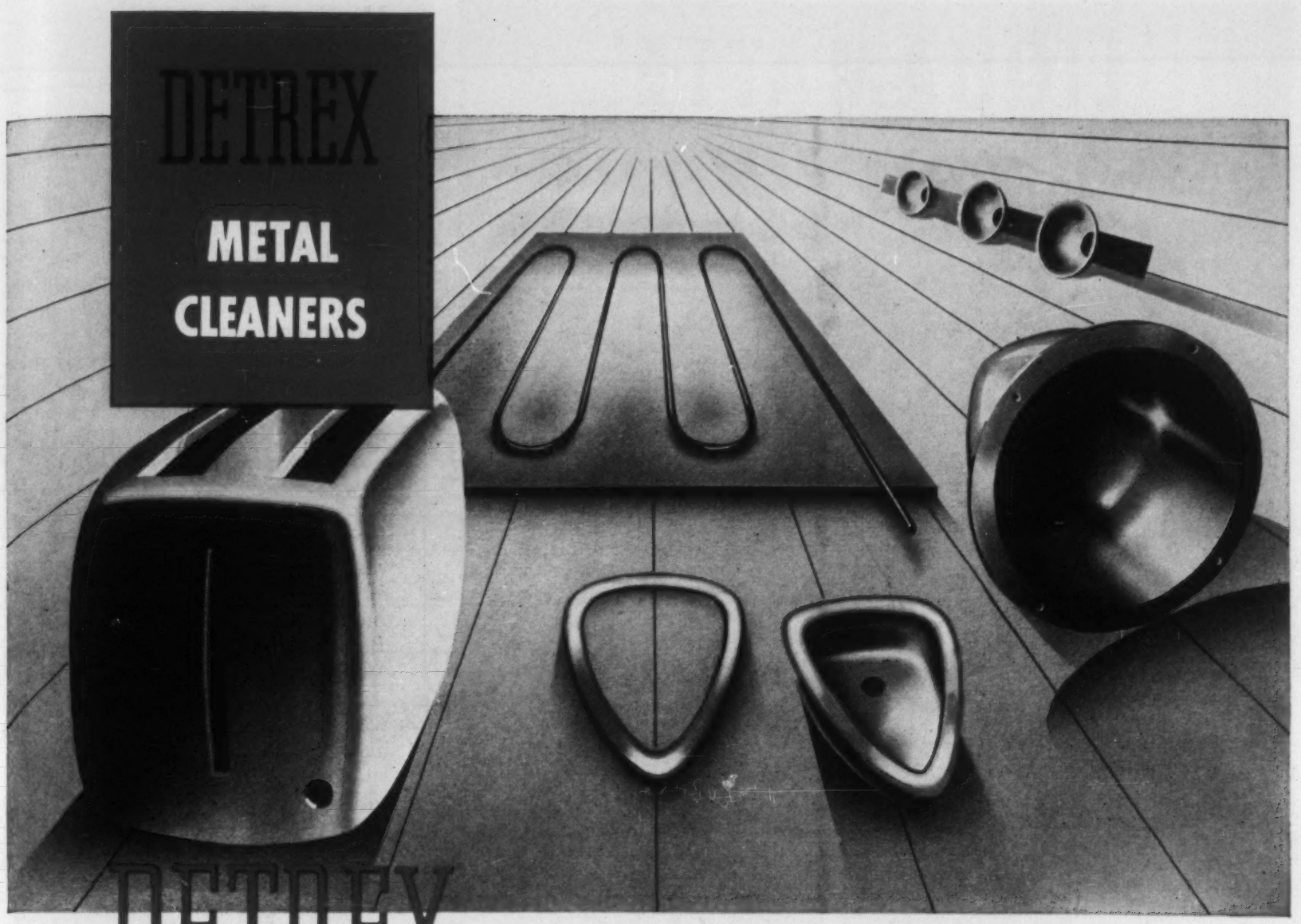
A special film holder permits the inspection of partially-completed welds by the McElroy-McNutt radiographic process while the metal is hot. A cooling fluid, circulating through the hollow chambers of the holder, protects the film emulsion from the heat of the welded section.

can be accomplished on a hot pipe, makes it practical to interrupt the welding operation to inspect the weld root where most flaws occur. This technique, therefore, saves the many man-hours of heating and controlled cooling that were formerly required before the weld could be inspected. Additional time is saved because, if defects are found, it is necessary to chip away only a partially-completed weld, rather than a finished weld.

As an example of the time saved by the hot radiography process, welding time on comparable sections of pipe at a large Eastern power plant was reduced from nine days to less than three days when the work was inspected by the new process. The technique can also be used for radiography of other forms of hot metallic materials.

Atomic Energy Commission Establishes Office of Industrial Development

The Atomic Energy Commission has established at its Washington headquarters a new Office of Industrial Development headed by Dr. William Lee Davidson, former di-



DETREX cuts cost 80% on all-purpose cleaning operation

A manufacturer of automotive and appliance parts wanted an all-purpose metal cleaner for his spray washer . . . daily production ranged from 8,000 to 50,000 zinc and aluminum die castings, steel stampings and drawn parts. Soil varied, too . . . vegetable, mineral and pigmented drawing compounds, light and heavy oils, chips and shop dirt had to be removed depending on the part run. A clean surface on all parts was essential since brightening, plating and painting operations followed cleaning.

The Detrex field engineer recommended Detrex 92 for the job. All parts now come out of the washer thoroughly clean . . . and "92" lasts a full week. The cleaner formerly used lasted only one day. Cleaner costs are reduced 80 per cent and labor costs are lower.

Get the facts about *your* cleaning operations. Without obligation, have a Detrex field engineer analyze your present method or help you plan a new operation—to give you increased production and cut your costs. Remember . . . only Detrex manufactures the alkalis, emulsions, degreasing solvents *and* the equipment—everything for a *complete*, guaranteed operation. Detrex field offices are located in principal industrial cities. Phone today or write **Detrex Corporation, Box 501, Detroit 32, Michigan.** A-2

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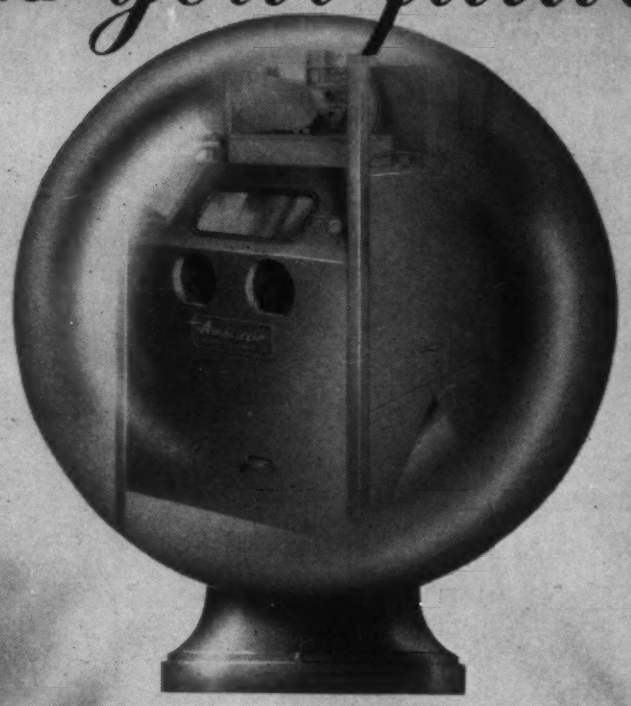
LIQUAMATTE and *your future*

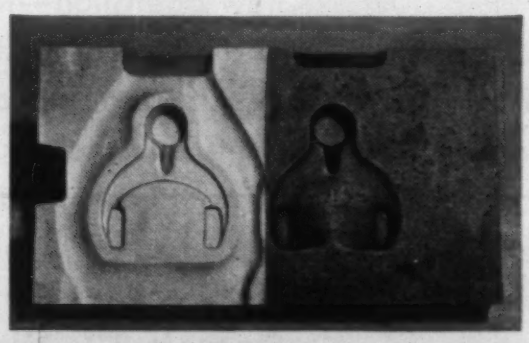


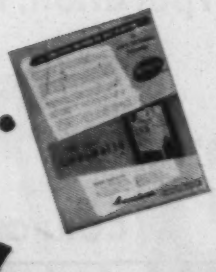
what SIMPLIFIED WET BLASTING means to you

The cost of close tolerance finishing can vary almost as much as the weather. Through development of wet blasting, large savings have been made possible in finishing costs . . . and now Liquamatte makes wet blasting EVEN MORE practical, economical and convenient. The Liquamatte has 14 advanced design features that overcome the many operating difficulties usually found in wet blasting. Thus it reduces finishing costs to the very minimum. With the Liquamatte, "hand" finishes are produced mechanically in a matter of seconds, eliminating many tedious operations. Precision parts can be processed while holding tolerances of .0001". Scale and directional grinding lines are uniformly removed, greatly prolonging the life of expensive tools and dies.

Liquamatte's 14 advanced design features mean 14-way savings for you. Send for Bulletin 23 and see.

Typical heat treated forging die, one half of which has been cleaned with the Liquamatte using a fine mesh Liquabrasive.





SEND TODAY FOR BULLETIN 23

It shows how Liquamatte's simplified design has reduced precision finishing costs to a new low.

American LIQUAMATTE WET BLASTING

WHEELABRATOR & EQUIPMENT CORP.

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News Digest

rector of physical research for the B. F. Goodrich Co., to handle the dissemination to industry of AEC technical data of primary importance in the fields of chemistry, metallurgy, specialized equipment and power generation.

M. W. Boyer, AEC general manager, said the purpose of the new office would be to aid in the administration of the industrial participation program—involving studies of power generation—and to expand the areas in which all types of industry may find an interest in the national atomic energy program.

"The Commission's program of industrial development," said Mr. Boyer, "will be a two-way exchange. We want to make sure that developments in the National atomic Energy Commission are promptly made available to the people interested.

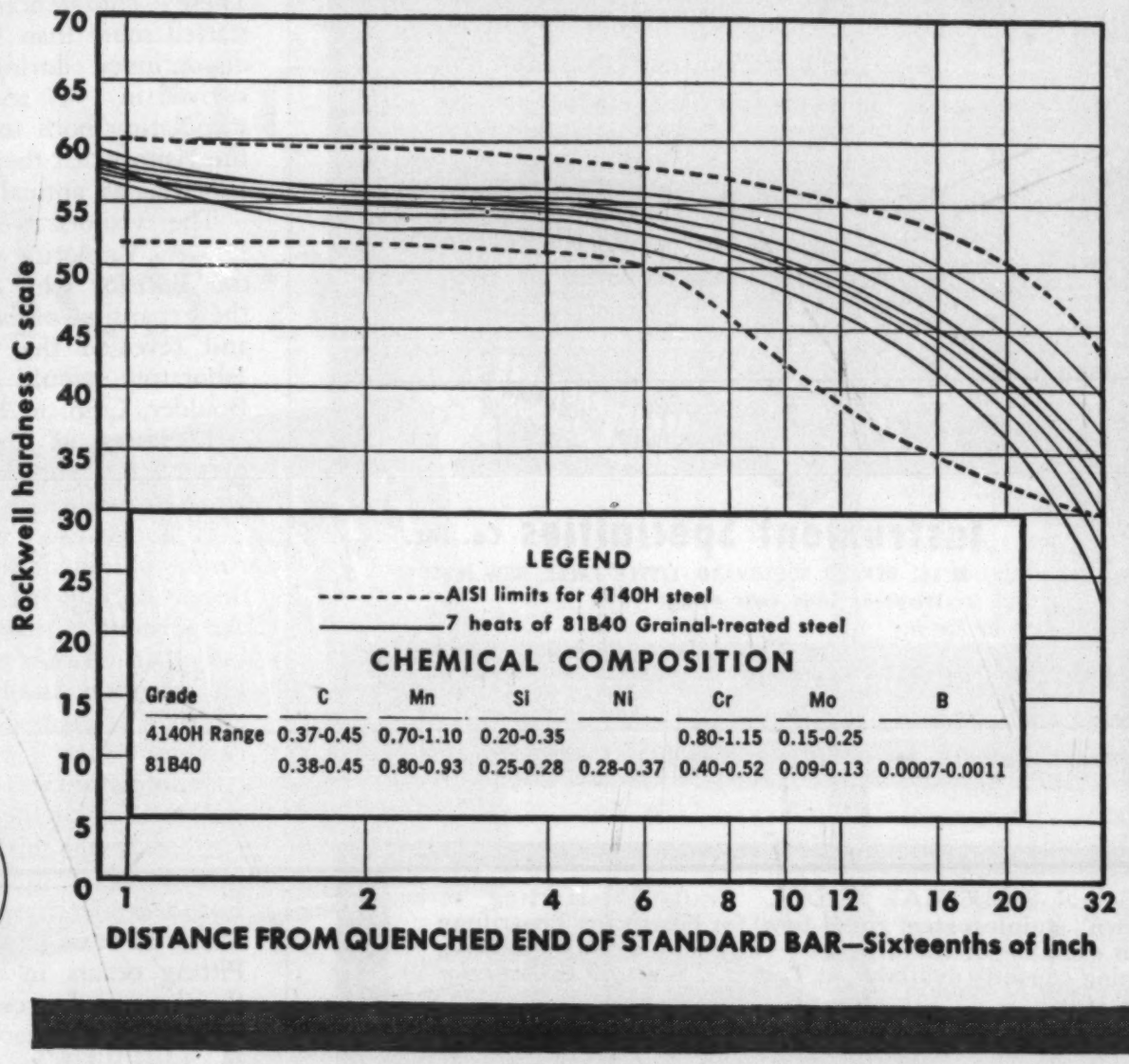
"Dr. Davidson's office will provide a single point of contact with responsibility to foster wider industrial participation in the Commission's program and the development of a more normal competitive approach to the problems and potentials of the atomic energy business.

"The Commission's establishment of an industrial development office has important long range implications, looking to the day when industry will carry on its own a substantial part of the national atomic energy program, with opportunity for real initiative. Of immediate importance, however, is the support of the present defense effort, which we expect to result from an intensive effort to bring about a fuller utilization of both government and industrial technological resources. This will require among other actions an expansion of the Commission's technical information services, which have been established as aids to research for the acquisition of new knowledge rather than for its application in industry."

NBS Holds Annual Metallurgy Division Conference

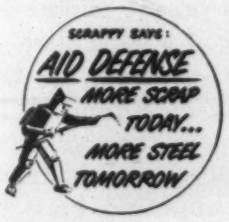
At a conference held on May 12 by the Metallurgy Div. of the National Bureau of Standards, 78 representatives of industry and Govern-

STANDARD (END QUENCH) HARDENABILITY CHART—



CHEMICAL COMPOSITION

Grade	C	Mn	Si	Ni	Cr	Mo	B
4140H Range	0.37-0.45	0.70-1.10	0.20-0.35		0.80-1.15	0.15-0.25	
81B40	0.38-0.45	0.80-0.93	0.25-0.28	0.28-0.37	0.40-0.52	0.09-0.13	0.0007-0.0011



Consistent Hardenability obtained in Boron Steels made with GRAINAL ALLOYS

The most common test for boron steels is measurement of hardenability by the end quench or Jominy hardenability test. Today's steel substitutions are made on the basis of similar hardenability since a reasonable prediction can thus be made of the hardness and strength of a given part.

The curves above show the relationship between the hardenability of a series of seven heats of 81B40 steel and the hardenability band for 4140H steel, which it often replaces. The 81B40 heats were made in one electric furnace shop, and the remarkably consistent hardenability shown by the curves was obtained by the use of Grainal alloy as the means of adding the boron.

Consistent hardenability means consistent strength and hardness after heat treatment, which is the aim of every fabricator. The best proof that the Grainal alloys insure this objective is found in the successful use of three million tons of Grainal-treated steels.

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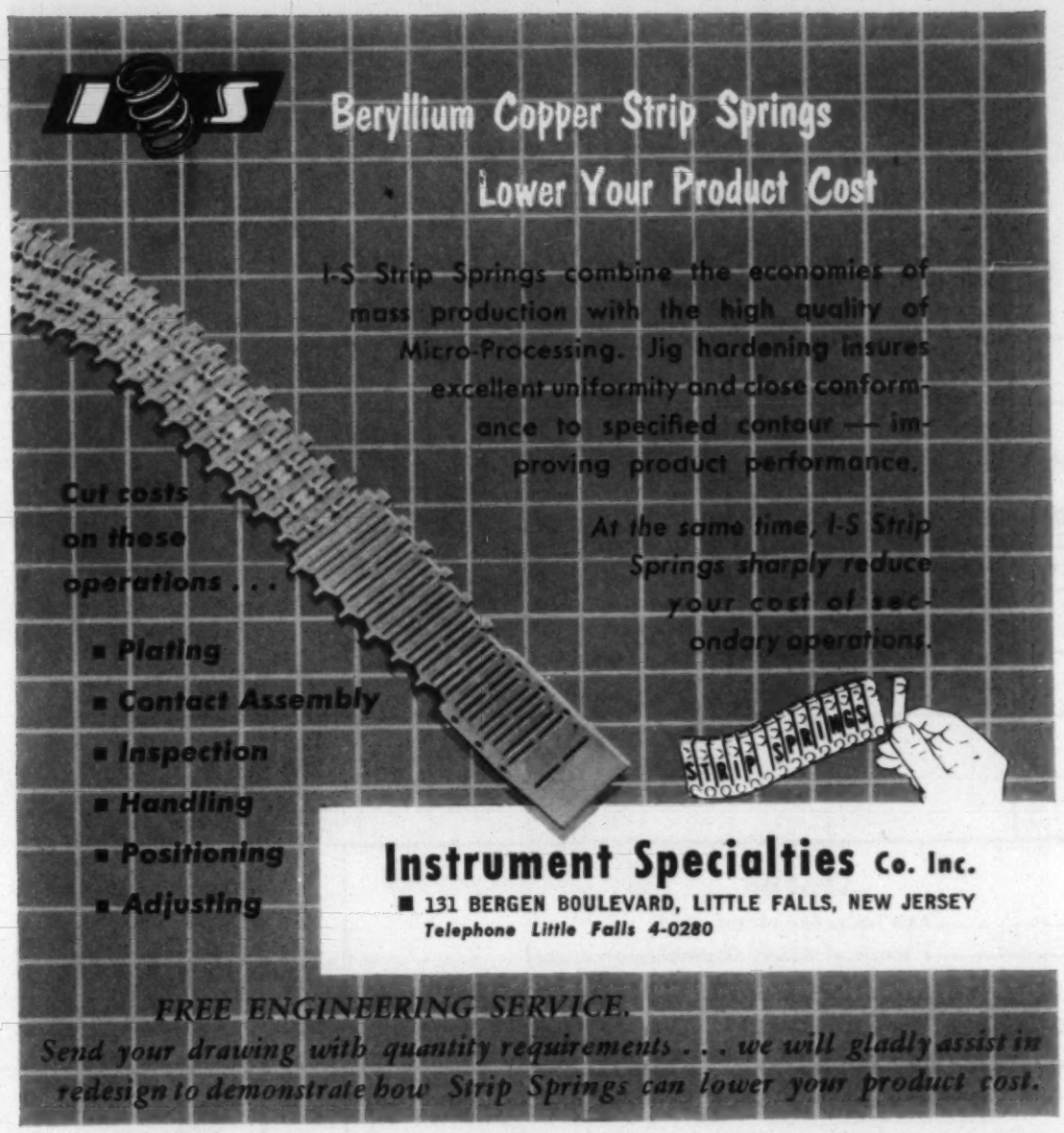
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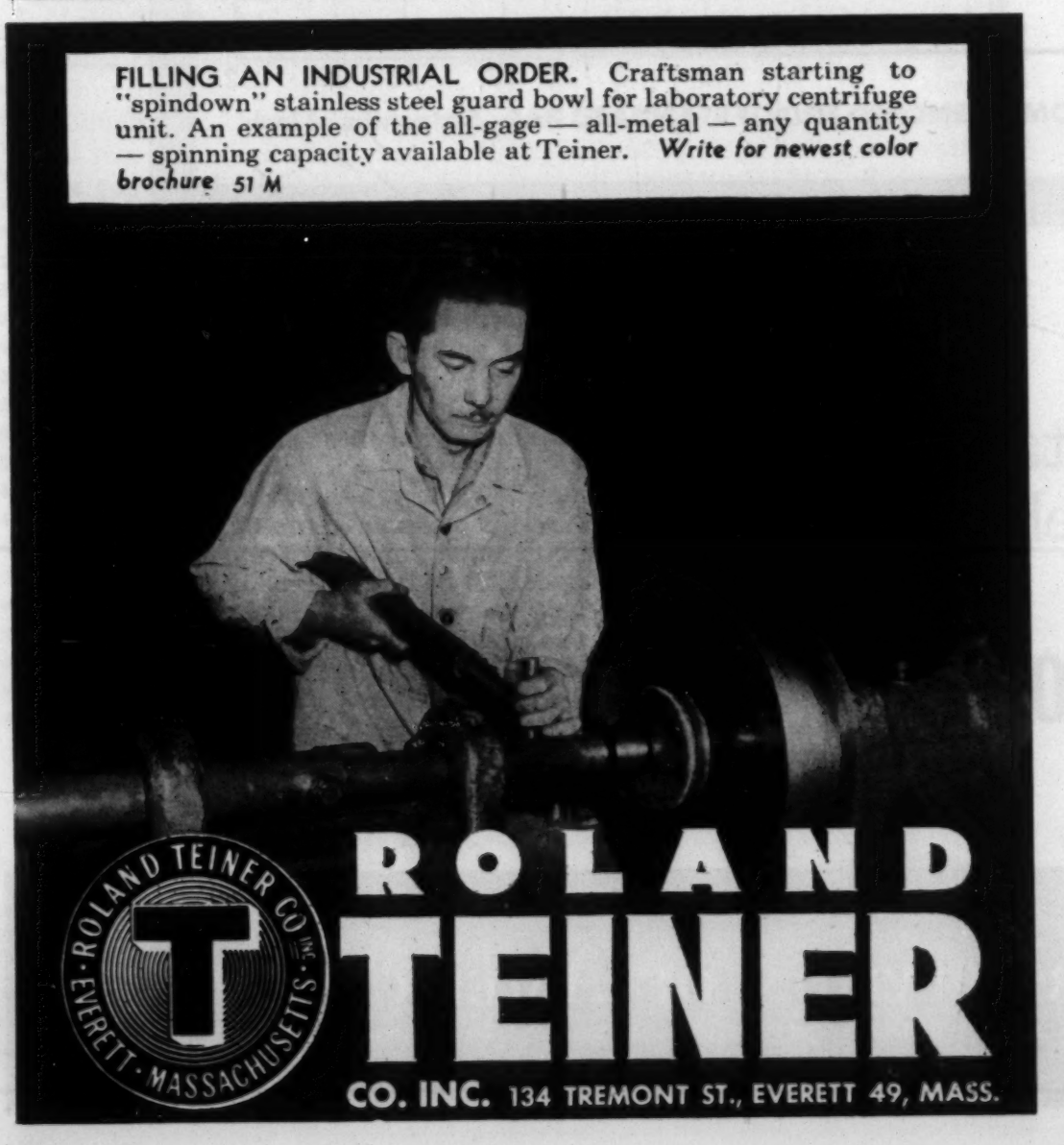
FILLING AN INDUSTRIAL ORDER. Craftsman starting to "spindown" stainless steel guard bowl for laboratory centrifuge unit. An example of the all-gage — all-metal — any quantity — spinning capacity available at Teiner. Write for newest color brochure 51 M
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News Digest

ment joined 47 members of the staff in a discussion of the metallurgical work in progress at the Bureau. These conferences, which were started more than 30 years ago, but discontinued during the war, were revived in 1947 and have proved so stimulating both to the staff and to the visitors that they have been established as an annual feature.

The visitors were welcomed by Dr. A. V. Astin, acting director of the Bureau, who reviewed, briefly, the expansion of laboratory facilities and revealed that a new radiation laboratory would be activated at Boulder, Colo. in 1954.

Members of the Division then presented reports of some of the work in progress:

I. A. Denison discussed the corrosion of zinc-iron compounds produced during hot dip galvanizing. As a result of his work on samples buried in alkaline soils for 13 years, Dr. Denison ascribes the protection afforded after destruction of the zinc coating to the formation of a film containing silicates on the surface of the metal or of the iron-zinc alloy.

Continuing his studies of the mechanism of stress-corrosion, H. L. Logan is investigating the stress-corrosion of brass in ammonia solutions. Pitting occurs in annealed brass in the absence of stress. Upon stressing, intercrystalline cracking occurs in alpha brass while transcrystalline cracking occurs in beta brass. Reasons for these differences are under investigation.

H. C. Vacher is studying crystal orientation with polarized light. The polarizer has been used for qualitative investigations of crystal orientation, and work is in progress to develop quantitative measurements.

Investigation of the variables affecting the martensite transformation by S. J. Rosenberg indicates that the M_s temperature has a tendency to rise with the increase in quenching temperature. Rosenberg postulates that this is caused by grain coarsening. In these tests the rate of cooling from the quenching temperature is not significant.

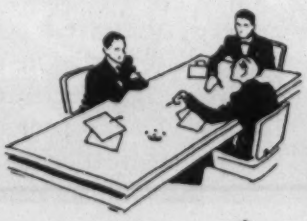
G. A. Moore reported the present status of the "pure" iron project. Dr. Moore announced an improved procedure for the production of high-purity iron which is expected to yield an iron of 99.999 purity. Such an iron is highly desirable for determining some of the fundamental proper-

Plastics add sales appeal

modern, eye-catching, protective—packaging that sells, made of STYRON 475

Sales of these home drills by ones and twos were good, but as the tool manufacturer expanded his production facilities, he encountered a new problem: how to sell these tools in multiple units, increase over-all sales and gain a wider share of the market. The manufacturer turned to a molder experienced in packaging and to the experts of Dow's Plastics Technical Service. The result was an attractive, durable case made of Styron 475 (Dow polystyrene) that had eye appeal and "buy appeal." This modern package contains 13 different-size drills, each protected from damage in its individual slot. This "working together"—the pooling of your own designers' talents, the molder's and Dow's—may help you improve *your* packaging and get a larger share of the market for your products. And shock- and moisture-resistant, lightweight but tough Styron 475 may be the material that will make your product *stand out* at the sales counter.

let's work it out together!



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did you KNOW

Three thousand years ago the inventive Egyptians isolated a resin from a species of balsam. This material was remarkably similar to today's styrene. It was used for embalming.

Twentieth Century research produced man-made styrene, a versatile chemical. Giving us synthetic rubber in our hour of need, it was made commercially possible through the plastics industry's search for better products. Chemistry transformed it into sparkling crystals of raw material for molding called "polystyrene." How well polystyrene has been tailored to the needs of today is demonstrated by its remarkable growth:

1938 . . . . . 190,000 lbs.
1948 . . . 150,000,000 lbs.
1951 . . . 250,000,000 lbs.

In thirteen years, a production increase of 130,000%! That's right—*one hundred and thirty thousand per cent.*

And the rate of application is doubling every four years! By 1955 this means a thousand pounds of polystyrene molded every minute of every day, all year long. Consider, too, that a pound of polystyrene will make a piece 7½ times larger than a pound of steel produces. Or, seven and one-half times as many parts of the same size.

What wonders we could show the Pharoahs!

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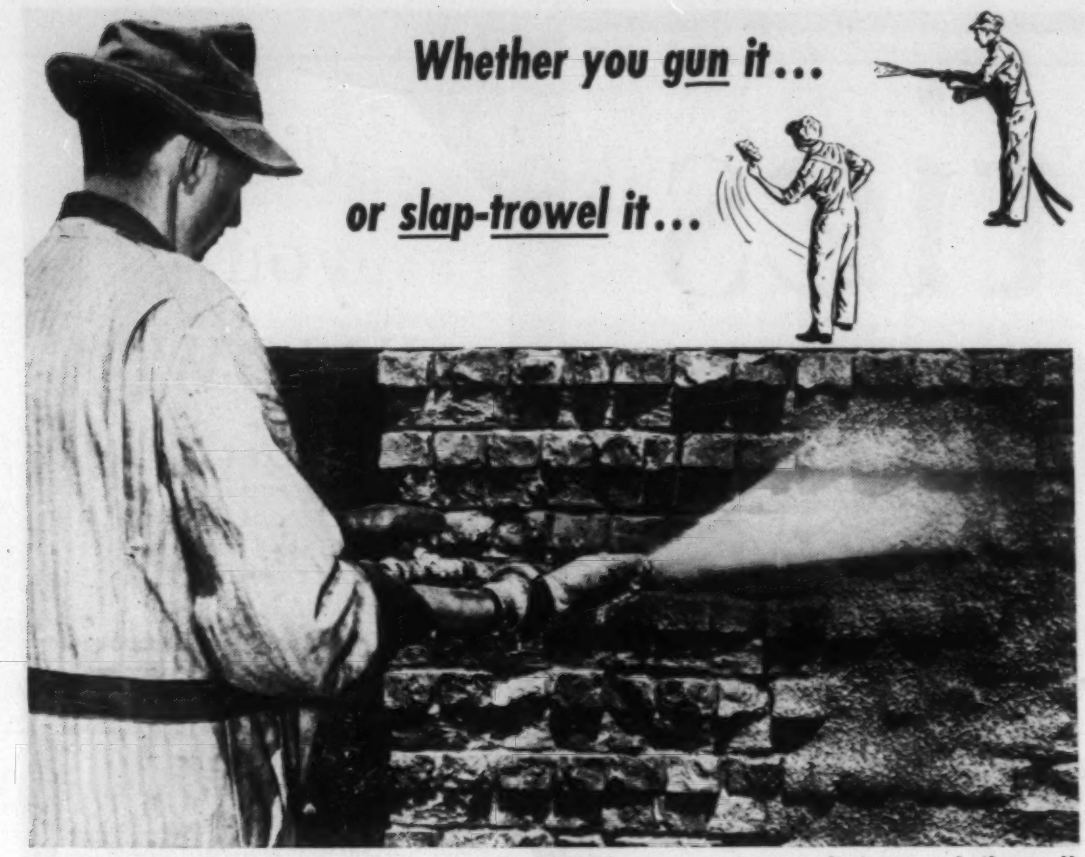

Gunning Blazecrete refractory lining on a boiler wall.

You get longer-lasting refractory linings with J-M BLAZECRETE

Blazecrete* is Johns-Manville's hydraulic setting refractory that you mix with water just as you'd mix ordinary concrete. Applied by gunning or slap-troweling, it builds linings that stand up longer in severe service.

You'll find that Blazecrete linings resist spalling, withstand slagging action, and are not harmed by rapid changes of temperature. In foundries . . . where refractories take real punishment . . . Blazecrete has increased ladle-lining life and lowered application cost.

Lining jobs move *fast* with Blazecrete, too. There's no laborious ramming or tamping required. And Blazecrete will not harm workmen's hands.

To meet various operating temperatures and service conditions, there are *three* types of Blazecrete . . . each a dry mix that can be stored indefinitely:

3X BLAZECRETE

For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for building and repairing forge furnace linings, lime kilns, burner blocks—and for lining ladles in ferrous and non-ferrous foundries.

STANDARD BLAZECRETE

For temperatures through 2400F. For building new and repairing old refractory linings. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Standard Blazecrete does not require pre-firing.

L. W. BLAZECRETE

For temperatures through 2000F. An *insulating* refractory . . . light in weight, low in thermal conductivity. For building new linings and repairing old. Adaptable and economical for many other applications.

All Blazecrete products harden on air curing . . . can then be fired or left standing indefinitely. For further details, send for Brochure RC-28A. It also tells about Blazecrete's companion material, Firecrete* . . . the hydraulic setting castable refractory for making special shapes and linings. Just write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario. *Reg. U.S. Pat. Off.

Johns-Manville **BLAZECRETE**

REFRACTORY LININGS

News Digest

ties of iron since small quantities of impurities significantly affect certain properties.

Continuing the series of investigations on the low temperature properties of materials, G. W. Geil discussed the deformation twinning in ingot iron at low temperatures. By means of a metallographic investigation of samples stressed at various temperatures from -193 C to 100 C, Geil showed that twinning occurs with the initial deformation, and high rates of strain are not necessary. These results are significant in the study of the mechanism of the brittle failure of steels at low temperatures.

In the afternoon, the Metallurgy Div. held an open house for the visitors, featuring exhibits of the work of the sections. On display was a series of four full-size airplane wing sections which had been exposed to a marine atmosphere for 7½ years. From visual inspection of the exteriors, a 302 stainless steel showed very little attack. An Alclad wing was in good condition, with some indications of sacrificial protection by the cladding. Both the painted and unpainted magnesium wings were also in good condition, with little evidence of corrosion.

New Tin-Nickel Electroplate and Bearing Alloys Discussed in Tin Research Institute Report

The annual Report of the Tin Research Institute for 1951 mentions a number of researches which reached the stage of commercial development during the year.

Foremost is the new tin-nickel electroplate, which is compared with chromium and is stated to have been found satisfactory for a wide range of domestic metalware, automobile parts and electrical appliances, including electric radiators. Interest in the new alloy plating was also stimulated by the large saving of nickel that is effected. Another alloy of tin, tin-zinc, in the proportions 80/20, has been adopted more generally as a protective plating for radio and television apparatus and for mechanical parts and fitments of

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These stainless steel wire inserts strengthen threads so greatly that stripping is eliminated, thereby allowing you to utilize the full tensile strength of each cap screw. You can:
(A) *use smaller cap screws*— (B) *use fewer cap screws*— (C) *use shorter thread engagement*— (D) *use cap screws in place of studs or bolt-and-nut assemblies*— (E) *use lighter bosses and flanges.*

Inexpensive *Heli-Coil* wire inserts, easily wound into slightly oversize tapped holes, remain permanently in place, providing easy-running female threads that are immune to wear, galling and corrosion.

The result is an improved product—cleaner looking, lighter, easier to service—frequently at reduced manufacturing cost.

Case histories, pointing up these benefits, are presented in *Heli-Call*, our engineering periodical which is yours for the asking. Use the handy coupon to put your name on the subscription list.

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cars, cycles, tools and machinery. Other new alloy coatings are being investigated.

Bearing alloys under examination included a selection of aluminum-tin alloys, which were found to have fatigue resistance superior to tin-base babbitt.

Tinplate investigations include work with an electrolyte circulating at speed past a fixed steel specimen—the reverse of industrial practice. Estimation of the corrosion resistance of the product by rapid methods has also been studied profitably.

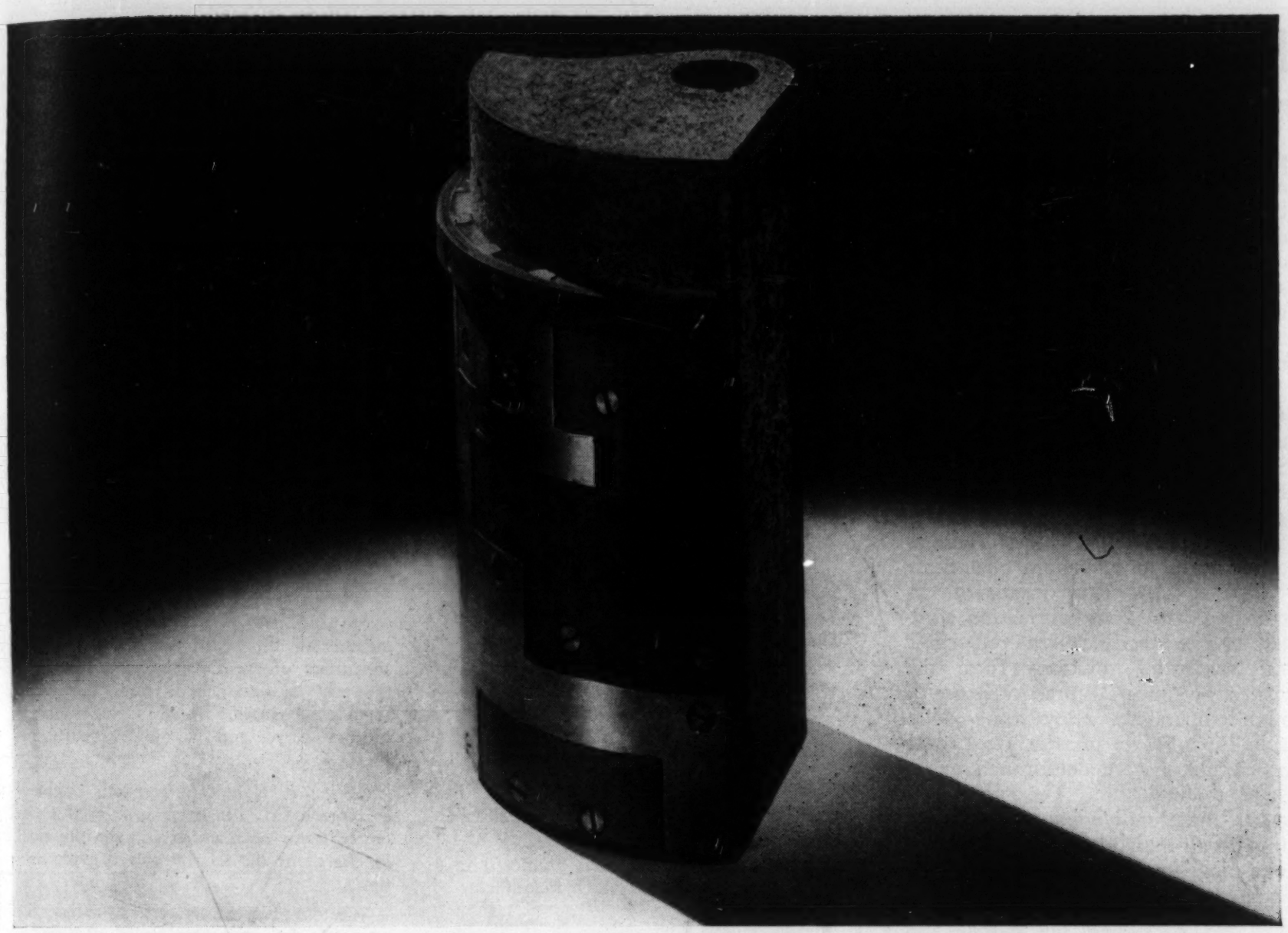
Further progress was made with the equipment for producing bars, rods and thick-walled tubes of bronze by casting molten bronze by a semi-continuous method. A new pewter that can be hardened by heat treatment was also announced during the year.

Assuming that the world's requirements of zinc concentrates approach a balance, it is possible that U. S. zinc smelters will achieve in 1952 an all-time peak production of one million tons of slab zinc, according to Charles R. Ince, vice president of the St. Joseph Lead Co., New York City.

NACA Research Reports

The National Advisory Committee for Aeronautics has published several research reports of interest to materials engineers in recent weeks. The reports and their abstracts follow:

"Abnormal Grain Growth in S-816 Alloy" A. I. Rush, J. W. Freeman and A. E. White, University of Michigan. (NACA TN 2678) Preliminary results are presented from an investigation to establish the fundamental causes of abnormal grain growth in S-816 alloy under conditions encountered during forging of blades for aircraft gas turbines. The data are confined to experiments to produce abnormally large grains in bar stock under controlled conditions. It was found that critical deformation for grain growth is apparently independent of temperature of deformation; re-



A controller contact drum assembly, constructed of Celoron, Vulcanized Fibre and Brass.

HERE'S A DRUM THAT'S *HARD* TO BEAT!

Ever wonder how a Diesel locomotive's speeds are controlled from stand-still to full speed? The throttle lever turns this contact drum, actuating governor solenoid controls which in turn control the speed of the Diesel engines. The throttle has ten positions: stop, idle, and running speeds one to eight. Each running notch on the throttle controller increases the engine speed in increments of 75 r.p.m., from 275 r.p.m. at idle to 800 r.p.m. at full throttle. A leading Diesel locomotive manufacturer designed this mechanism which uses two C-D-F materials to do a job requiring unusual insulating and mechanical strengths.

The drum body is molded C-D-F Celoron, a macerated canvas-filled phenolic material. The special shape, a sector of a cylinder, is uniformly molded and is half the weight of aluminum . . . dimensionally stable . . . of superior electrical and mechanical strength. Eight and a half inches high, the drum has been drilled and broached; brass screws attach a cast brass contact surface, milled to give the desired contact arrangement.

Tough, flexible C-D-F Vulcanized Fibre is between the contacts, enabling the contact fingers to slide from the metal to the insulated surface without dipping into the space between the contacts. Fibre was specified because of its unusual arc extinguishing and non-tracking characteristics. Whenever a circuit is broken, the resulting arc is drawn out across the surface of one of the Vulcanized Fibre segments, thereby protecting the surface of the phenolic drum from the arc.

If you have an insulating problem, probably a C-D-F product is the answer. C-D-F manufactures and fabricates electrical insulation, laminated and molded plastics, Micabond and Teflon tapes and sheets. Sales offices are located in principal cities. Call your C-D-F sales engineer—he's a good man to know!

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peated critical deformations between reheats to 2150 F produce much larger grains than a single critical deformation; grain growth characteristics are sensitive to prior history; and abnormal grain growth can be induced by temperature cycling alone to temperatures of 2150 F with certain prior histories.

"Survey of Proportions of the Chromium-Cobalt-Nickel-Molybdenum Quaternary System at 2192 F." Sheldon Paul Rideout and Paul A. Beck, University of Notre Dame. (NACA TN 2683) A survey was made of portions of the chromium-cobalt-nickel-molybdenum quaternary system at 2192 F by means of microscopic and x-ray diffraction studies. Since the face-centered cubic (alpha) solid solutions form the matrix of almost all practically useful high-temperature alloys, the solid solubility limits of the quaternary alpha phase were determined up to 20% molybdenum. The component cobalt-nickel-molybdenum, chromium-cobalt-molybdenum, and chromium-nickel-molybdenum ternary systems were also studied. The survey of these systems was confined to the determination of the boundaries of the face-centered cubic (alpha) solid solutions and of the phases coexisting with alpha at 2192 F.

News of Engineers

In an expansion of its technical research program, Ryan Aeronautical Co. has appointed *Alexander Pechman,* ceramic engineer, to the staff of its Development Laboratories.

General Electric Co. has announced the following appointments within its organization: *Alan Howard* has been appointed manager of the Turbine Div.'s Engineering Dept., and *John P. Keller* has been named general manager of the Gas Turbine Dept. Four appointments have been announced in the company's newly formed Industry Control Dept. *Joseph T. Bailey* has been named manager of marketing; *F. Wiley Hubbell,* manager of finance; *William F. Oswalt,* manager of manufacturing; and *Hal W. Poole* has been named manager of engineering. In the Appliance Control Dept., *Arnold Dunn* has been made manufacturing engineer; *Alden L. Thomas* has been named superintendent of the Morrison Plant; *Thomas J. Kelley* has been appointed design engineer. The appointment of *William E. Miller* as manager of the Steel Mill Section of the company's Industrial Engineering Dept. has also been announced.

J. D. Greensward has been appointed manager of a newly organized Apparatus Dept. at Allis-Chalmers Manufacturing Co., according to a recent announcement. Mr. Greensward will continue as general manager of the company's Norwood Works. Also announced by the company is the appointment of *Eugene P. Morton* as assistant engineer in the process lab.

Standard Steel Corp. has announced the promotion of *C. N. Rees* to vice president in charge of manufacturing.

S. K. Andersen has been promoted to chief engineer of AiResearch Manufacturing Co.

Appointment of *Harrison C. Blankmeyer* as scientific director, Fiberglas Research and Development Laboratories, Owens-Corning Fiberglas Corp., has been announced. Mr. Blankmeyer will assist in coordinating product development and process improvement programs.

The appointment of three vice presidents to head 12 of the 31 divisions of the Westinghouse Electric Corp. has been announced. *W. W. Sproul* has become vice president in charge of the general industrial products group of divisions, which comprise the Micarta, Standard Control, Small Motor, Elevator, Sturtevant, Welding and Lighting Divs., and the Bryant Electric Co. *L. B. McCully* has been named vice president in charge of the East Pittsburgh Div.: Transportation and Generator, and Switchgear. *H. E. Seim* has become vice president in charge of the Sturtevant Div. and also the Bryant Electric Co. *A. W. Edwards,* a company engineer, has been awarded a Sloan Foundation Fellowship to study for a year at the MIT School of Business and Engineering Administration. Mr. Edwards was one of 18 technical graduates chosen by the Foundation from a national field of 50.

Pittsburgh Coke & Chemical Co. has announced the election of *W. Kenneth Menke* to the newly created post of vice president in charge of chemicals.

Richard V. D. Strong, formerly Chicago district manager, has been appointed chief engineer of the F. J. Stokes Machine Co.

The election of *Fred A. Collinge* as chairman of the board and of *John A. Collinge* as president and general manager has been announced by The G. M. Diehl Machine Works, Inc.

Floyd E. Harris has been appointed a member of the board and chief research consultant of the Dow Furnace Co. For the past 35 years, Mr. Harris has been furnace engineer, Buick Div., General Motors Corp., and has just recently retired.

Loring F. Coes, Jr., research engineer at Norton Co., has been appointed assistant director of research and development in charge of the laboratory's organic section.

Western Electrochemical Co. has announced the appointment of *Robert S. Burns* as president, succeeding *Kenneth Walsh,* who has been elected chairman of the executive committee. Mr. Burns was formerly president of Standard Steel Corp. He will continue his connection with the company as chairman of the board of directors.

K. R. Troyer has been named vice president of Columbia Machinery and Engineering Corp.

Three important changes of personnel within Magnaflux Corp. have been announced. An entirely new major position, that of 2nd vice president in charge of engineering, has been created. Named to head this office is *Hamilton Migel,* previously 2nd vice president and eastern man-

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DEVELOPED FROM TURCO'S FLEXIBLE DY-CHEK PROCESS. ACCEPTED BY THE AIR FORCE... AND BY THE NAVY
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LASTING VISIBILITY OF FLAW INDICATIONS PERMITS ECONOMICAL RE-WORKING AT YOUR CONVENIENCE.
RE-WORK WELDERS SAY
MAKES EACH JOB EASIER BECAUSE WE CAN SEE WHERE THE DEFECTS ARE!

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Belmont's informative "Metal-of-the-Month" letters — write for your copies

Thorough attention to customer orders is a "must" in the metallurgical field . . . metal products need to meet precise requirements alloy-wise as well as dimensionally. Belmont brings you 50 years of positive, conscientious service — efficiently supplying customers *what they want* — and a Belmont commitment can be relied upon to be an exact fulfillment of your order.

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A Vital Heritage
INDIVIDUAL INCENTIVE

News Digest

ager. *Roy O. Schiebel, Jr.,* currently Midwest manager in Chicago, will move to New York as eastern manager. *Kermit A. Skeie* follows Mr. Schiebel as Midwest manager.

Howard S. Bunn has been appointed president of Bakelite Co., a division of Union Carbide and Carbon Corp. Formerly, Mr. Bunn held the position of vice president of Bakelite and Carbide & Carbon Chemicals Co., both divisions of Union Carbide.

Thomas D. Cartledge has been named president of Linde Air Products Co., a division of Union Carbide and Carbon Corp. Mr. Cartledge has been senior vice president of Linde, and a director and vice president of Dominion Oxygen Co., Ltd., a Union Carbide subsidiary.

Officers and directors have been named for Asahi-Dow Ltd., recently-formed associate of Dow Chemical International Ltd. and The Asahi Chemical Industry Co. Vice president is *Max Key,* assistant production manager of Dow Chemical's Saran Dept., while the president is *Tadayoshi Kitamura,* former managing director of Asahi Chemical.

Dr. *R. H. Bundy,* manager of the Dow Chemical Co.'s Plastics Dept. since 1945, has been named to head the company's research activities.

R. L. Maxwell, Major-General, U. S. Army (Ret.), vice president in charge of personnel and public relations of American Machine and Foundry Co., has been elected a vice president of the American Ordnance Association's New York post.

John C. Sharp has been elected president, general manager and a director of Hotpoint, Inc., to succeed *James J. Nance,* who resigned to become president of Packard Motor Co. Mr. Sharp previously held the positions of vice president and chief engineer.

Robert H. Bobilin, formerly a member of the engineering staff of the Udylite Corp., has been appointed chief engineer of the Davies Supply and Manufacturing Co.

Dr. *Fred Olsen,* vice president of research and development, Olin Industries,

CHIEF INSPECTORS REPORT
KEEPS ACCEPTABLE PARTS MOVING...ONLY SUSPECTED PARTS GO TO TRAINED INSPECTORS. SIMPLIFIES EVALUATION, CUTS DEPARTMENT COSTS.
PRODUCTION SUPTS. SAY
ELIMINATES INSPECTION BOTTLENECKS. PERMITS ONE MAN TO CHECK AS MANY PARTS PER HOUR AS HE CAN PICK UP AND PUT DOWN!
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SAVES IN-SHOP-HANDLING TIME. PERMITS IN-PROGRESS INSPECTIONS. AN EXCELLENT RECEIVING DEPARTMENT TOOL. YOUR PEOPLE WILL LIKE IT!

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Metal Spinning Division
PHOENIX PRODUCTS CO.
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SEE OUR CATALOG IN SWEET'S
For Product Designers

News Digest

Inc., has been elected president of the Industrial Research Institute, Inc.

At a recent meeting of the board of directors, *Frank J. O'Brien, Jr.* was elected a vice president of Metal & Thermit Corp.

According to a recent announcement from Pyrene Manufacturing Co., *Frederick G. Hoppe* has been named manager of the Metal Finishing Div.

Wellman Bronze & Aluminum Co. has announced the appointment of *James M. Robertson* as Chief chemist in charge of quality control at all plants. *Robert C. Boehm* has been named as the company's new chief metallurgist, while *Robert W. Spacek* has been appointed assistant production manager for all plants.

G. Howard Le Fevre was elected vice president and manager of Metal Sales for the New York office of United States Smelting, Refining & Mining Co.

L. F. Reinartz, vice president, Armco Steel Corp., was recently awarded the Regional Technical Meeting Award of the American Iron and Steel Institute. The award, in stainless steel, is given for the paper of outstanding merit in the regional programs of the previous year.

Emanual Gordon has joined the Engineering Dept., Metal Hydrides, Inc., where he will be in charge of special pilot plant operations. *Robert D. Gray* has been appointed superintendent of the company's Expanded Chemical Hydrides Div.

W. C. Whitehead has been named acting general manager of The Garrett Corp., in the absence of *J. C. Garrett,* president, who is taking an extended rest.

Dr. *Karl B. McEachron,* General Electric Co. engineer, has received the 1952 award of the Engineering Societies of New England. Dr. McEachron is manager of the company's Laboratory-Engineering Dept., Transformer and Allied Products Div.

Pennsylvania Precision Casting Co. has announced the appointments of *Robert A. Ziesing* as ceramics engineer and *Howard E. Snyder* as quality control engineer. Mr. Ziesing was formerly a metallurgist in the Ceramics Dept. and foreman of the molding room, Alloy Precision Casting Co. Mr. Snyder was previously research engineer, Radar Mechanical Design Section, Hughes Aircraft Co.

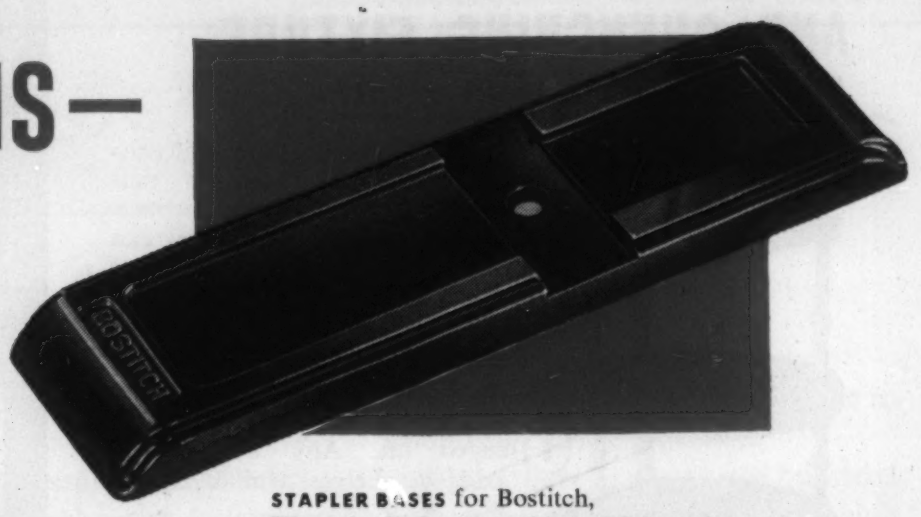
A. E. Harrant has been named executive vice-president of Miller Electric Manufacturing Co. and *A. C. Mulder* has been appointed vice president in charge of production.

The death of *John Jay White,* founder and president since 1929 of Tube Reducing Corp., has been announced by the company.

United States Steel Corp. has announced the death of *John Lester Perry* who was

A "BASE" FOR FASTER OPERATIONS—

fast-curing G-E 12853 molding compound!



STAPLER BASES for Bostitch, Westerly, R. I., are molded of fast-curing G-E 12853 compound by Teal Molding Corp., New Haven, Connecticut.

Looking for a plastics material to help you obtain the parts you need more quickly and economically? Then consider General Electric's *fast-curing* 12853 molding compound. This quick-curing plastics means *more parts per press* . . . effects economies while producing sturdy parts with high gloss and excellent electrical properties.

Reductions in cure times from 16 to 40% have been realized when conventional general-purpose compounds were replaced with fast-curing G-E 12853!

Ask your molder about G-E 12853. He benefits, too, because this versatile compound works equally well in compression, transfer and plunger-type molds . . . helps him reduce inventory.

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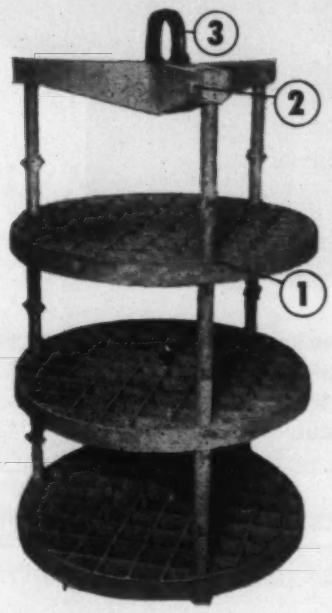
has more lives than a cat!



DURABLE design and construction materials that will see it through the furnace time after time. Any part can be replaced separately. Posts are passed through slotted holes in grids (1) then given a half turn to lock grid in place. Yoke (2) is keyed onto posts. Lifting hook (3) is keyed on. Any number of grids or shelves available.

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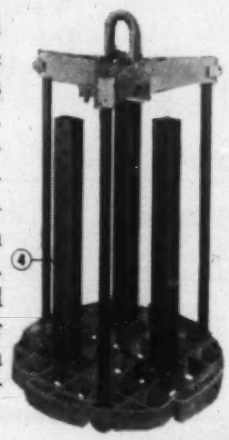
Bottom grid is available with tubes (4), 1" dia. up, perforated to overcome "gusher action" in quenching. Parts such as spiders, ring gears, and collars can be slipped over tubes for secure handling. Also types with spacers to support shafts. Send for literature.



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In ordinary furnaces, as much as 3/64 in. of a billet may peel off in steel-wasting scale.

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143-S

News Digest

president, successively, of U. S. Steel's Tennessee Coal, Iron and Railroad Co.; Carnegie-Illinois Steel Corp.; and Columbus Steel Co. Mr. Perry, who was 71, retired from active service on Nov. 15, 1948.

News of Companies

The world-wide rights for the commercial development of all of its inventions pertaining to lead have been awarded to *Knapp Mills, Inc.*, for a period of 18 years by the *American Viscose Corp.*

The Carborundum Metals Co., Inc., a new subsidiary of *The Carborundum Co.*, has signed a contract with the *Atomic Energy Commission* for the production of zirconium and hafnium metal. Niles C. Bartholomew was appointed vice president of the new company.

Merritt Products Co. has announced the formation of a *Plastic Specialties Div.* with Don Conroy as manager.

Exterior work has recently been completed on the new one-story unit abutting the present two-story structure which houses the *Eastern Brass & Copper Co.* at 1122 E. 180 St., Bronx, N. Y. The unit adds 17,000 sq. ft. to the present floor space.

Construction is expected to be completed soon on a new 86- by 74-ft. concrete building at the West Allis Works of *Allis-Chalmers Manufacturing Co.* to house a 22 million-volt betatron for use in inspecting large steam turbine, centrifugal pump and hydraulic turbine parts produced by the firm.

Kidde Manufacturing Co., Inc. has recently purchased a 64-acre tract of land in Roseland, N. J. Although no immediate plans have been prepared, the company proposes to build a modern plant on this tract to fabricate two types of knitting machines.

L. J. Wing Manufacturing Co. recently held a reception and open house for all employees, families and friends. A feature of the occasion was the presentation of service awards by the company's president.

A Research Center has been established in Philadelphia by the *Valve Div., Minneapolis-Honeywell Regulator Co.* to support an extensive development program in industrial valves.

American Cyanamid Co.'s program of grants and fellowships to universities this year included 17 graduate fellowships in chemistry and chemical engineering. They were awarded to graduate students in their final pre-doctoral year of study and carry a stipend of $1500, plus full tuition and incidental laboratory fees. They also

JOHNSON BRONZE

SLEEVE BEARING DATA

CAST BRONZE

JOHNSON BRONZE

SLEEVE BEARING DATA

Selecting the Alloy

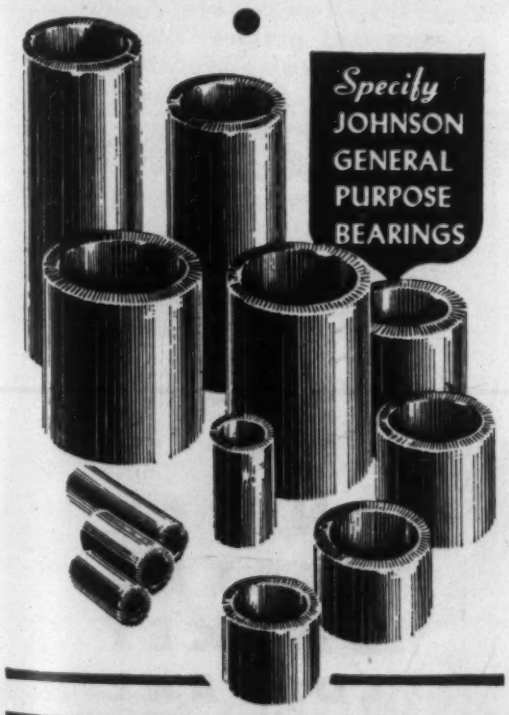
The many and various applications for sleeve-type bearings make necessary the availability of a variety of bearing metals possessing many distinctly different properties. Each particular bearing metal must be best suited for those conditions of service wherein its outstanding characteristics will be of greatest advantage. Accordingly, in the selection of a bearing material it is necessary that the service conditions and the destructive forces on the bearing be analyzed first and the bearing material be then selected for each specific application.

The first step is to accumulate accurate operating data such as speeds and loads . . . whether constant or intermittent . . . method of lubrication; the presence of acid, harmful chemicals, gases, grit or dust; the type of shaft to be used.

All sleeve bearings operate in direct contact with the shaft until the creation of the necessary film of lubricant. Consequently, the following physical properties govern the suitability of a bearing metal: (1) Plasticity; (2) Ability to Resist Wear; (3) Coefficient of Friction; (4) Compressive Strength; (5) Resistance to Pounding; (6) Toughness.

While there are over one hundred bronze bearing alloys from which to make your selection, we have found through experience that the following will meet practically every application.

Johnson Bronze Alloy No.	Average Chemical Composition				
	Copper Cu	Tin Sn	Lead Pb	Zinc Zn	Nickel Ni
19	70.0	11.0	19.0	. . .	. . .
25	75.0	5.0	19.0	. . .	1.0
27	80.0	10.0	10.0	. . .	. . .
29	78.0	7.0	15.0	. . .	. . .
51	87.0	10.0	1.0	2.0	. . .
53	88.0	10.0	. . . .	2.0	. . .
55	86.0	12.0	. . . .	2.0	. . .
66	85.0	5.0	9.0	1.0	. . .
71	85.0	5.0	5.0	5.0	. . .
72	83.0	7.0	7.0	3.0	. . .



Stock Size Bearings

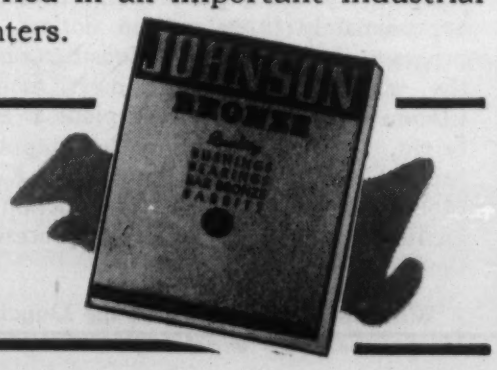
For ordinary service applications and for quick, easy replacement Johnson Bronze maintains a stock bearing service that comprises over 850 individual sizes. This includes inside diameters from ¼" to 4¼"; outside diameters run from ⅜" to 4½"; lengths are available from ¾" to 8". All of these sizes can be quickly altered and any type oil groove, slot or hole can be economically added. Complete stocks are carried in all important industrial centers.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

Catalogue

Over eighty pages fully illustrated. Lists and describes the most complete stock bearing service in the market. Write for your free copy.



This bearing data sheet is but one of a series. You can get the complete set by writing to—

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1. Sicon Protects Gas Heater Combustion Chambers at 875°

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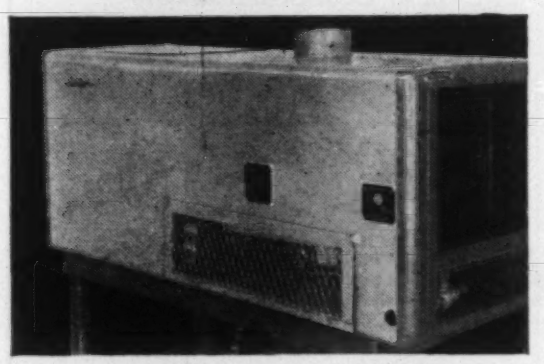

CENTRAL GAS HEATER
Mfg'd by the JOHN ZINK CO., TULSA

For years the protection of combustion chambers and outer coverings of heating equipment has been a problem.

The John Zink Company, a leading manufacturer of gas heaters, solved this problem with SICON.

SICON protects their combustion chambers against extreme high heats of 875° without powdering or losing its color.

SICON, in attractive colors, also preserves the outside appearance of their products, adding greatly to sales appeal, and prolonging life.

The John Zink Company now uses SICON for all hot applications.

Inside and outside—SICON is the finish that can often do the job where all others fail.

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News Digest

include $300 for unrestricted use by the Dept. of Chemistry or Chemical Engineering of the student's university. American Cyanamid also announced plans to build a plant near New Orleans for the production of chemicals from natural gas.

A new plant for the manufacture of Speed Nut fasteners in Canada was recently opened by *Dominion Fasteners, Ltd.*, in Hamilton, Ont.

This year marks the 125th anniversary of the *Joseph Dixon Crucible Co.*

Shields Rubber Co. is moving its Chicago branch operations into larger quarters at 108-112 Clinton St., according to a recent announcement.

Pacific International Products, Inc. has announced the establishment of new headquarters in the Boothe Bldg., 475 Huntington Dr., San Marino, Calif.

Two Detroit machine tool builders have won top awards for design excellence of their products. *Michigan Tool Co.* was given an award for its new ultra high-speed hobbing machine that produces teeth on gears, and *Modern Industrial Engineering Co.* received an award for its Burr-Master chamfering machine that removes burrs and sharp corners from the edges of gear teeth. The awards were made by *Design News* magazine.

Preliminary construction has just begun on a $980,000 plant at Scarborough, Ont. by *Acme Steel Co. of Canada, Ltd.*, a subsidiary of *Acme Steel Co.*, Chicago.

Reichold Chemicals, Inc. has announced the establishment of a new *South Atlantic Div.* at Jacksonville, Fla., heralding an entrance into a new field — cellulose chemistry.

Ground was broken recently for a 6 million dollar steam and gas turbine development laboratory at the S. Philadelphia Works of the *Westinghouse Electric Corp.* Actual construction of the four-story, brick, structural steel building will begin late this summer, and will take about a year to complete. It will employ a staff of nearly 100 engineers and technicians, and initially will conduct special research for the U. S. Air Force.

Superior Plastics Co. was recently picked as the best Junior Achievement plastics company by a panel of *The Society of the Plastics Industry.*

Foote Mineral Co. recently announced plans for a three-way expansion of the company's lithium production. Involving approximately three million dollars, the program includes: (1.) Construction of the world's largest and most modern lithium chemical processing plant at Sunbright, Va. (2.) Tripling the output of lithium ore at its property near Kings Mountain, N. C. (3.) Construction of facilities for quarrying and processing limestone at Sunbright, Va.

What has been known as the Dunellen, N. J., plant of *Worthington Corp.* has

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PROFIT from our broad experience and greater "know-how," and our completely modern specialized facilities for rapid, low-cost production.

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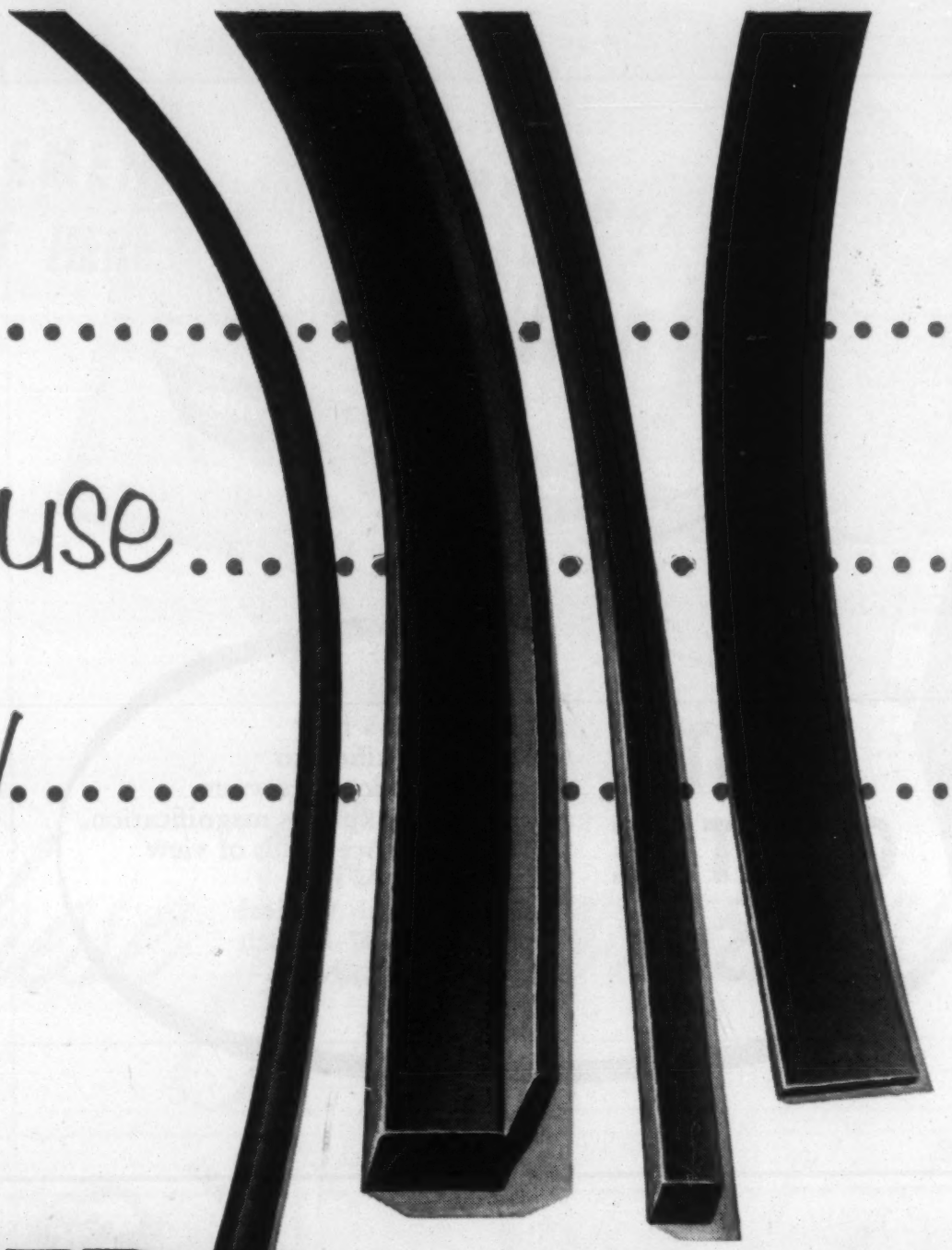

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Here's a valuable new addition to the 3M line of automotive products . . . 3M extruded sealers.

3M extruded sealers come in a variety of sizes, ready-made for fast, hand application on your production line. 3M extruded sealers eliminate the need for pressure extruding equipment and make possible a quick, on-the-spot seal. *And,* if you need a special shape extrusion, 3M will die-cut one to your specifications!

An additional feature of some 3M extruded sealers is their expansion when heated. These sealers swell about *50% under heat* and cure to tough, rubber, gasket-like seals especially valuable when faying surfaces are irregular, and a completely tight seal is necessary. These sealers give a high degree of adhesion, and can be painted over handily.

Ask your 3M salesman to show you his line of extruded sealers . . . they are tailor made for the auto industry. Like all 3M products, extruded sealers are *engineered* for top quality and performance, ready to do a bang-up job for you! For more information about 3M extruded sealers write 3M, Dept. 67, 411 Piquette Avenue, Detroit 2, Mich.

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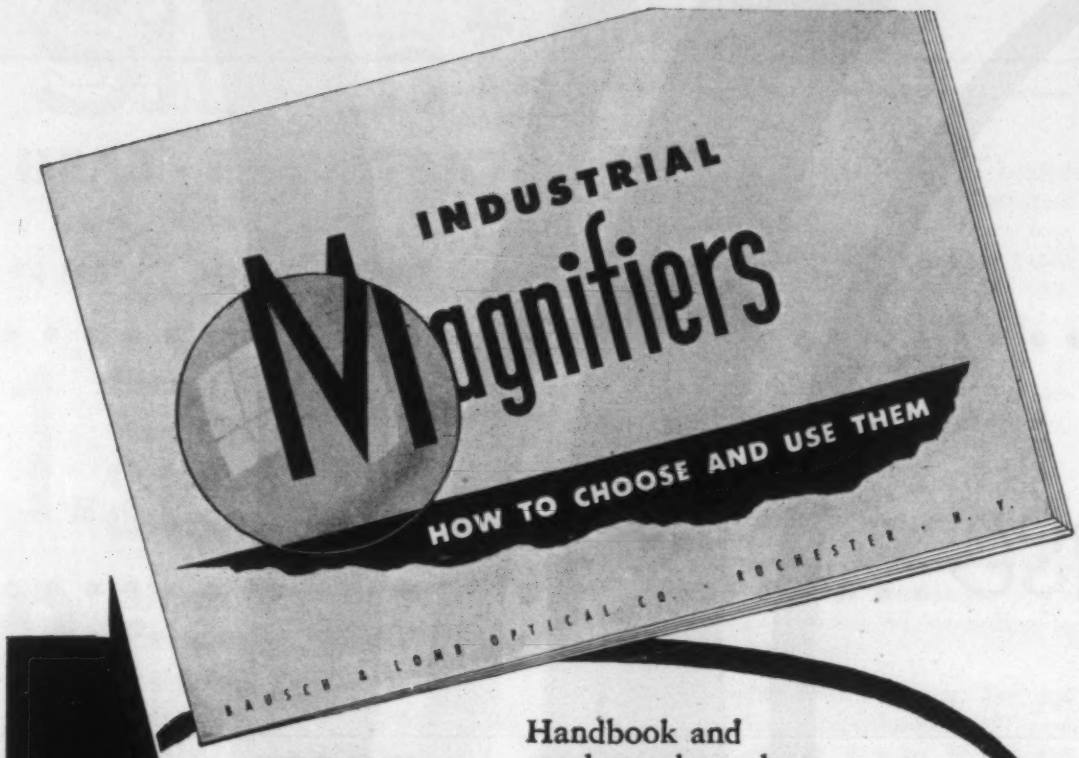

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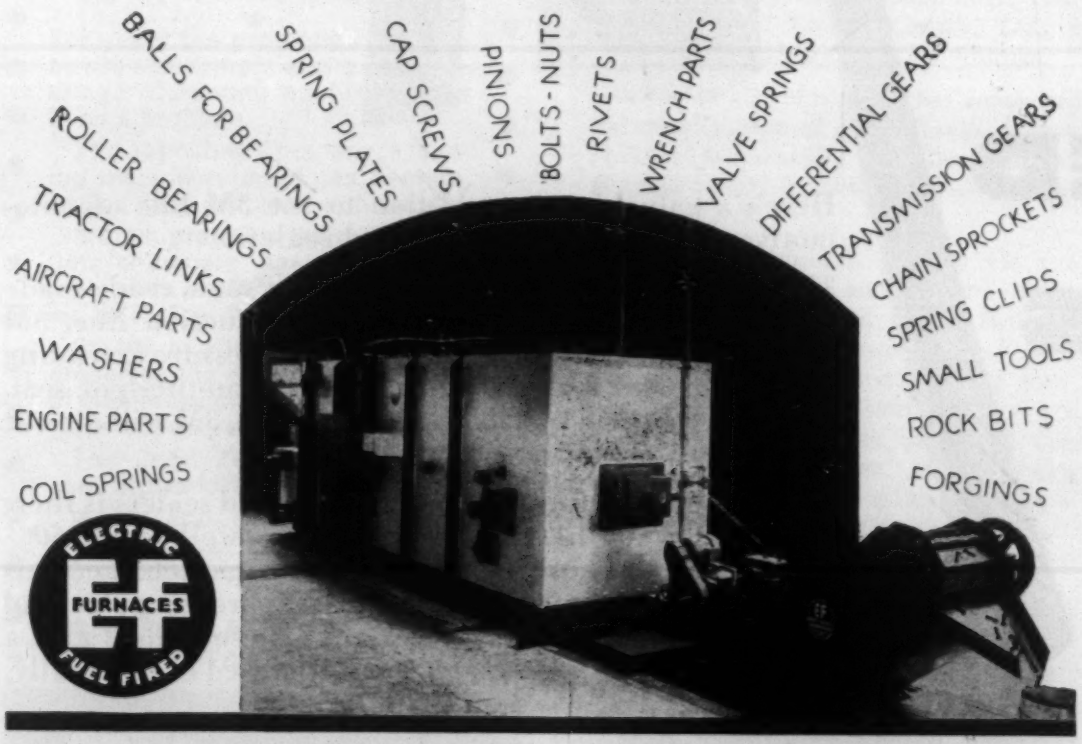

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175 to 2000 Lbs. per Hr.

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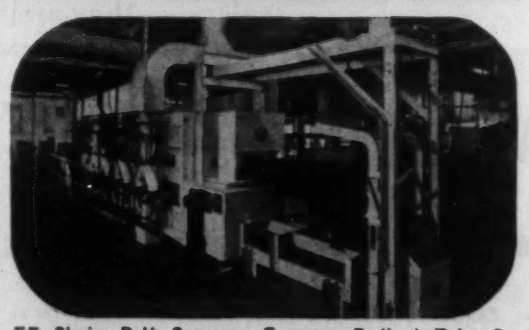
WILSON STREET, SALEM, OHIO
Gas Fired, Oil Fired and Electric Furnaces



EF Chain Belt Conveyor Furnace, Radiant Tube Gas Heated, Showing Labor Saving Loading Arrangement. (In the view at the top) Electrically Heated Furnace Showing Automatic Quench and Discharge.

News Digest

been redesignated as the Plainfield Works The address now reads: Plainfield Works, Plainfield, N. J.

Colonial Aluminum Smelting Corp. recently put its new secondary aluminum smelter into operation for the production of secondary aluminum ingots conforming to strict laboratory specifications.

Chatham Electronics Corp. has announced the start of construction of a new plant located in Livingston, N. J.

In order to expand its service to its customers in Rochester, *Pratt & Whitney* has relocated its branch office in a new, modern building at 845 Main St., W., Rochester 11, N. Y.

The new standard carbide tool fabricating plant of the *Carboloy Dept., General Electric Co.,* at Edmore, Mich., was shown to employees and their families and to local residents at open house festivities on June 5. The newly completed 45,000 sq.-ft. plant is now mass producing standard carbide tools on a production line basis. Another announcement from G-E indicates that a multimillion-dollar transformer manufacturing plant, providing employment for about 1700 persons, will be built at Rome, Ga. Construction will begin at once, and the expected completion date is mid 1953.

News of Societies

The Gas Appliance Manufacturers Association recently elected James F. Donnelly, an executive of the A. O. Smith Corp., as president. Other officers elected include: Sheldon Coleman, president of The Coleman Co., as first vice president; T. T. Arden, vice president, Grayson Controls Div., Robertshaw-Fulton Controls Co., second vice president. Lyle C. Harvey, president of Affiliated Gas Equipment, Inc., was re-elected treasurer.

The retirement of Walter S. Tower, president of *American Iron and Steel Institute,* has been announced. Max D. Howell, vice president and treasurer of U. S. Steel Corp., was elected to the newly created post of executive director of the Institute.

William E. Cramer, president, Industrial Ceramic Products, Inc., became the 54th president of *The American Ceramic Society* when he took office at the 54th annual meeting held in Pittsburgh. Other officers installed were: R. R. Danielson, president-elect; Victor C. Swicker, Harry H. Holscher and H. B. DuBois, vice presidents; and Edwin M. Rupp, treasurer. Charles S. Pearce, general secretary, is starting his eighth year in that office. Total registration at the meeting was 2113 members and guests.

At the eighth annual meeting of the *Metal Powder Association* recently held

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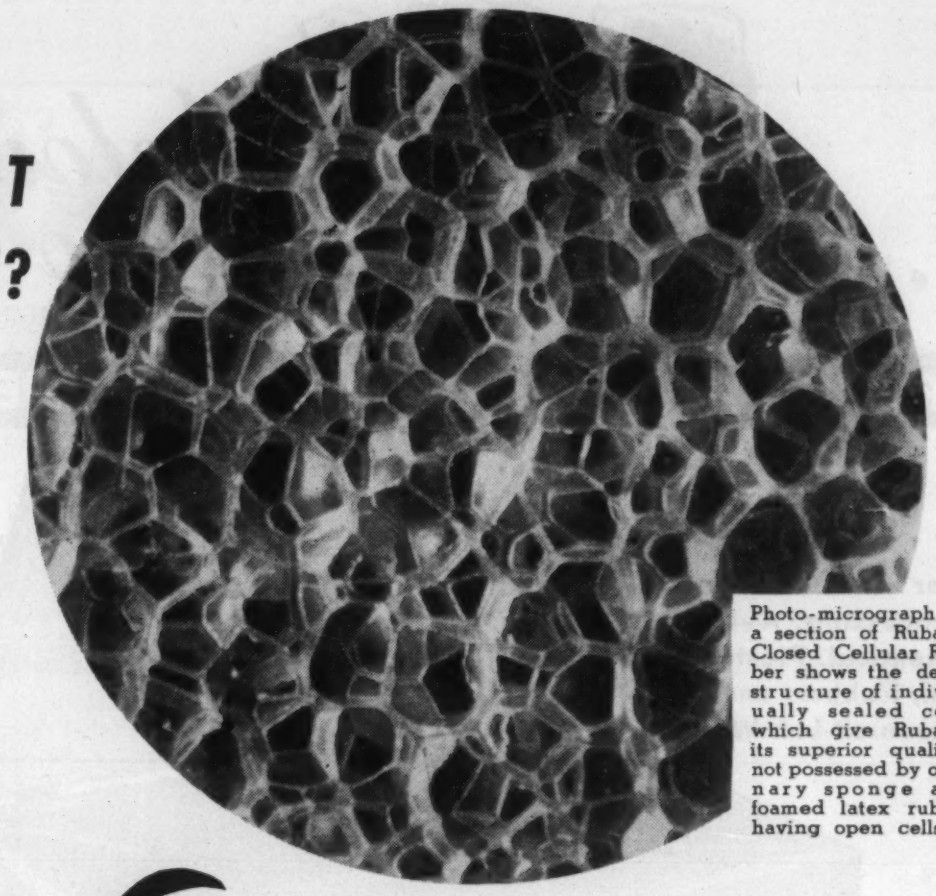

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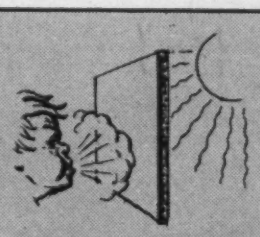
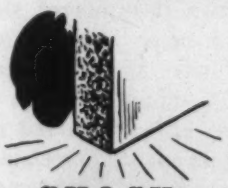


INSULATOR

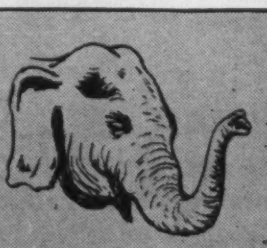
LIGHT WEIGHT



SHOCK ABSORPTION

BUOYANT

SANITARY



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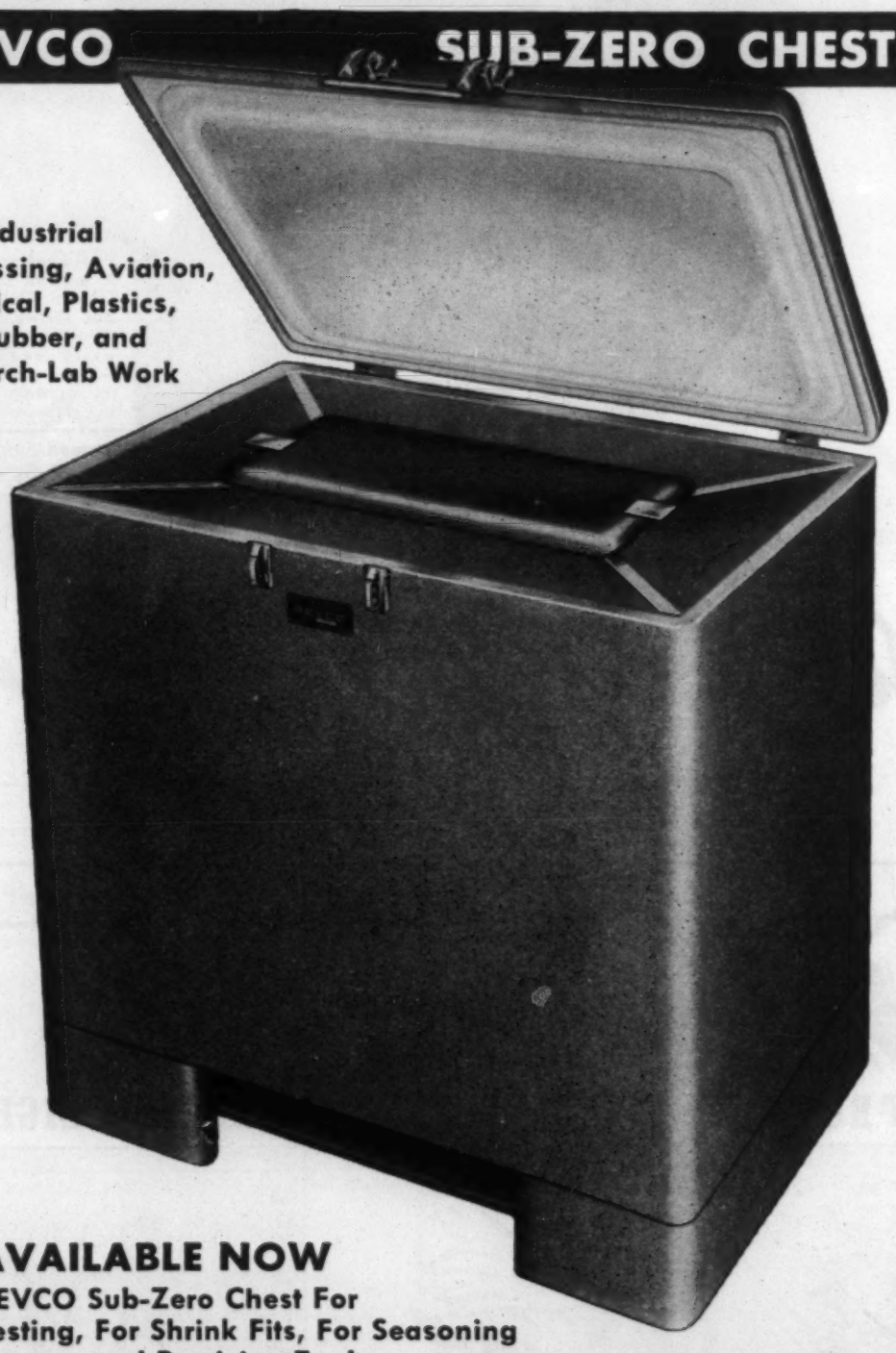

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REVCO Sub-Zero Chest For Testing, For Shrink Fits, For Seasoning Gauges and Precision Tools . . . Completely equipped ready for operation, will accommodate parts or assembled units up to 23″ long, 12½″ deep, 9″ high in the 1.5 Cu. Ft. model and up to 47″ long, 16″ deep and 15″ high in the 6.5 Cu. Ft. model. Revco Sub-Zero Chests are designed and built to meet highest performance standards. They feature temperatures of 95° and 85° below zero, respectively, upon continuous running in normal room temperature. Other controlled Low-Temperatures readily attained.

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News Digest

in Chicago, the following officers were elected for the forthcoming year: Ernest H. Klein, manager, Metal Div., New Jersey Zinc Sales Co.—president; Thomas Moore, sales manager, Antara Chemicals Div., General Dyestuff Corp.—vice president. Mr. Klein succeeds Thomas L. Robinson, president of the Wel-Met Co., who was elected chairman of the board.

Heading the roster of new officers of the *American Foundrymen's Society* elected at the Society's annual business meeting during the 1952 International Foundry Congress is president-elect I. R. Wagner, Electric Steel Castings Co. Vice president-elect for 1952-53 is Collins L. Carter, Albion Malleable Iron Co. The following awards were made at the International Foundry Congress: To Henton Morrogh —The William H. McFadden Gold Medal "for outstanding work and development in the field of spheroidal cast iron"; To Albert Portevin—The Joseph S. Seaman Gold Medal "for technical contributions over many years to the arts and sciences of the Foundry Industry"; To Frank G. Steinebach—The John A. Penton Gold Medal "for outstanding contributions to the foundry industry and the Society"; To Albert P. Gagnebin and Keith D. Millis—The Peter L. Simpson Gold Metal "for outstanding work and development in the field of spheroidal cast iron." Honorary life memberships were given to: William G. Mixer, Alexander I. Krynitsky and Walter L. Seelbach.

The National Association of Corrosion Engineers have moved to 1061 M. & M. Bldg., No. 1 Main St., Houston 2, Tex.

Porcelain Enamel Institute has opened its doors to new membership and states that three distinct types of manufacturers are eligible to become active members. They are (1) "captive" porcelain enameling plants (manufacturers of stoves, refrigerators and other porcelain enameled products who have their own enameling facilities); (2) suppliers to the industry, including those allied with frit manufacturers; (3) independent porcelain enameling companies engaged in enameling the products or components of other manufacturers.

American Society of Tool Engineers has announced the appointment of Allan Ray Putnam as assistant executive secretary.

The executive committee of the board of trustees of the *Institute of Gas Technology*, affiliated with the Illinois Institute of Technology, has confirmed the appointments of Director E. S. Pettyjohn as vice president, of Dr. J. D. Parent as dean, and of Henry R. Linden and C. G. von Fredersdorff as assistant research directors.

An upsurge of industrial scientific research in the field of metallurgy has brought about the establishment of a department of metallurgy at *Southwest Research Institute*. Appointed to head the department is Dr. Robert J. Anderson.

DO YOU HAVE *tough* X-RAY INSPECTION JOBS?

At the American Steel Foundries' plant in Newark, New Jersey, heavy steel castings are easily X-rayed due to equipment *flexibility.*

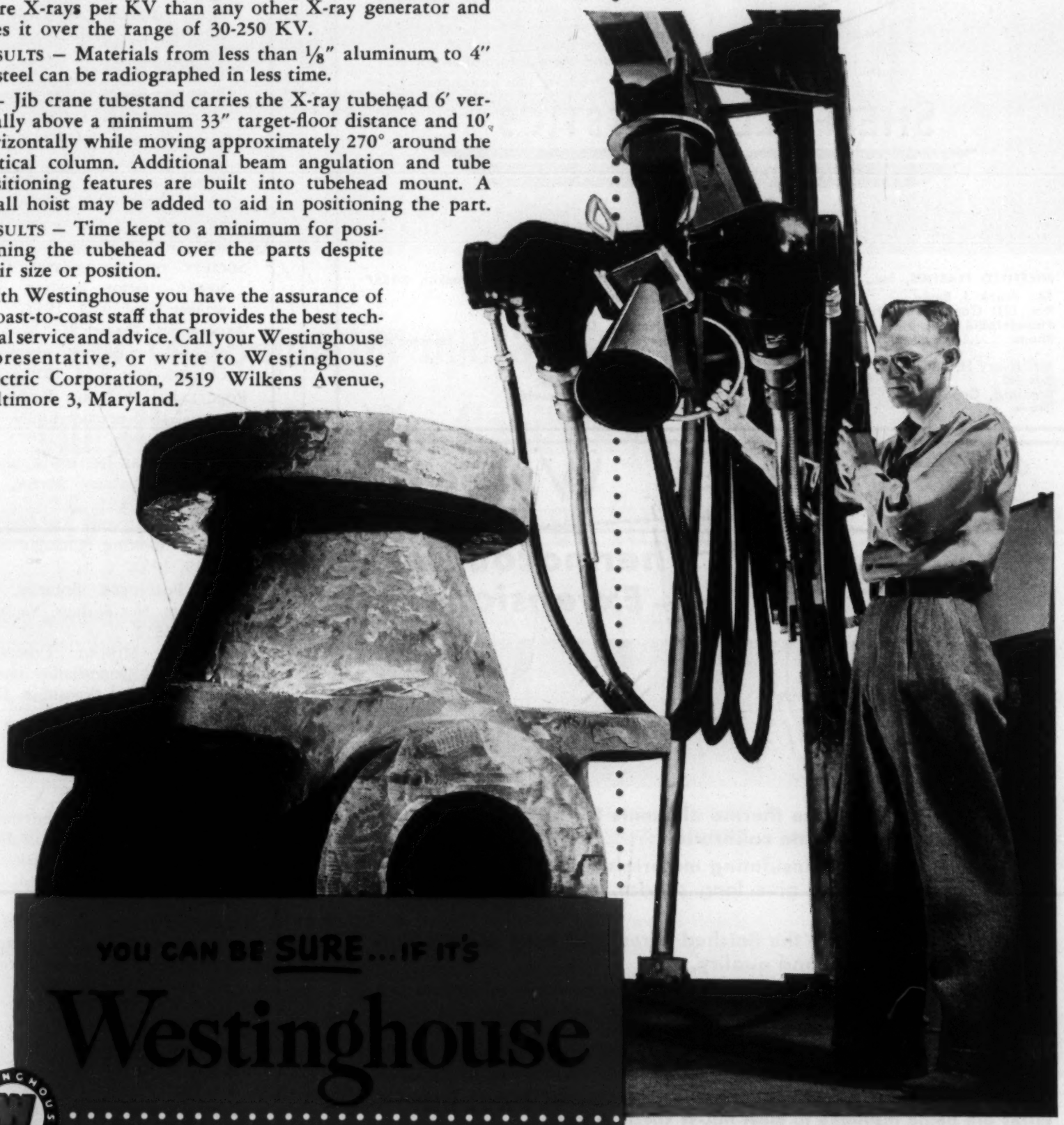
1 – *Constant Potential* high voltage generator produces more X-rays per KV than any other X-ray generator and does it over the range of 30-250 KV.

RESULTS – Materials from less than 1/8" aluminum to 4" of steel can be radiographed in less time.

2 – Jib crane tubestand carries the X-ray tubehead 6' vertically above a minimum 33" target-floor distance and 10' horizontally while moving approximately 270° around the vertical column. Additional beam angulation and tube positioning features are built into tubehead mount. A small hoist may be added to aid in positioning the part.

RESULTS – Time kept to a minimum for positioning the tubehead over the parts despite their size or position.

With Westinghouse you have the assurance of a coast-to-coast staff that provides the best technical service and advice. Call your Westinghouse representative, or write to Westinghouse Electric Corporation, 2519 Wilkens Avenue, Baltimore 3, Maryland.



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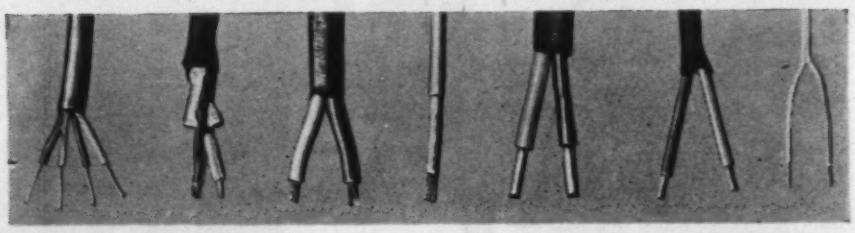
Thermo Electric Wires for Thermocouples Extensions



ACCURATE because the thermo elements for all wires are carefully matched for accurate calibration.

DURABLE because all insulating materials are carefully selected, applied and treated to give long service, even under abnormal conditions.

DEPENDABLE because the finished wires must meet *ALL* our high standards of accuracy and quality.

Thermo Electric Wires are made for all standard thermocouple calibrations and are insulated with the latest types of plastics, asbestos and fiberglass. The fibrous insulations are compound saturated for added protection against moisture and abrasion. For severe abrasive conditions, a metallic wire or ribbon is braided directly over the outer insulation.

MIL-W SPECIFICATIONS—Iron Constantan and Chromel Alumel Extension Wires are being insulated to meet MIL-W specifications.

For detailed specifications—write for Wire Bulletin 30G

Thermo Electric Co., Inc.

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Meetings and Expositions

INTERNATIONAL TRADE FAIR. Chicago. Aug. 2-17, 1952.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. San Francisco. Aug. 11-13, 1952.

OAK RIDGE SUMMER SYMPOSIUM. Oak Ridge, Tenn. Aug. 25-29, 1952.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Industrial Minerals Div. fall meeting. Chicago. Sept. 3-6, 1952.

AMERICAN STANDARDS ASSOCIATION, national standardization conference. Chicago. Sept. 8-10, 1952.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Chicago. Sept. 8-11, 1952.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments & Regulators Div. and INSTRUMENT SOCIETY OF AMERICA, exhibit and joint conference. Cleveland. Sept. 8-12, 1952.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting. Milwaukee. Sept. 9-11, 1952.

AMERICAN CHEMICAL SOCIETY, national chemical exposition. Chicago. Sept. 9-13, 1952.

PORCELAIN ENAMEL INSTITUTE, annual shop practice forum. Urbana, Ill. Sept. 10-12, 1952.

PRESSED METAL INSTITUTE, annual meeting. Pocono Manor, Pa. Sept. 14-18, 1952.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Sept. 18-19, 1952.

STEEL FOUNDERS' SOCIETY, fall meeting. Hot Springs, Va. Sept. 22-23, 1952.

AMERICAN MINING CONGRESS, metal and nonmetallic mining convention and exposition. Denver. Sept. 22-25, 1952.

NATIONAL ELECTRONICS CONFERENCE. Chicago. Sept. 29-Oct. 1, 1952.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual convention. Cleveland. Sept. 30-Oct. 3, 1952.

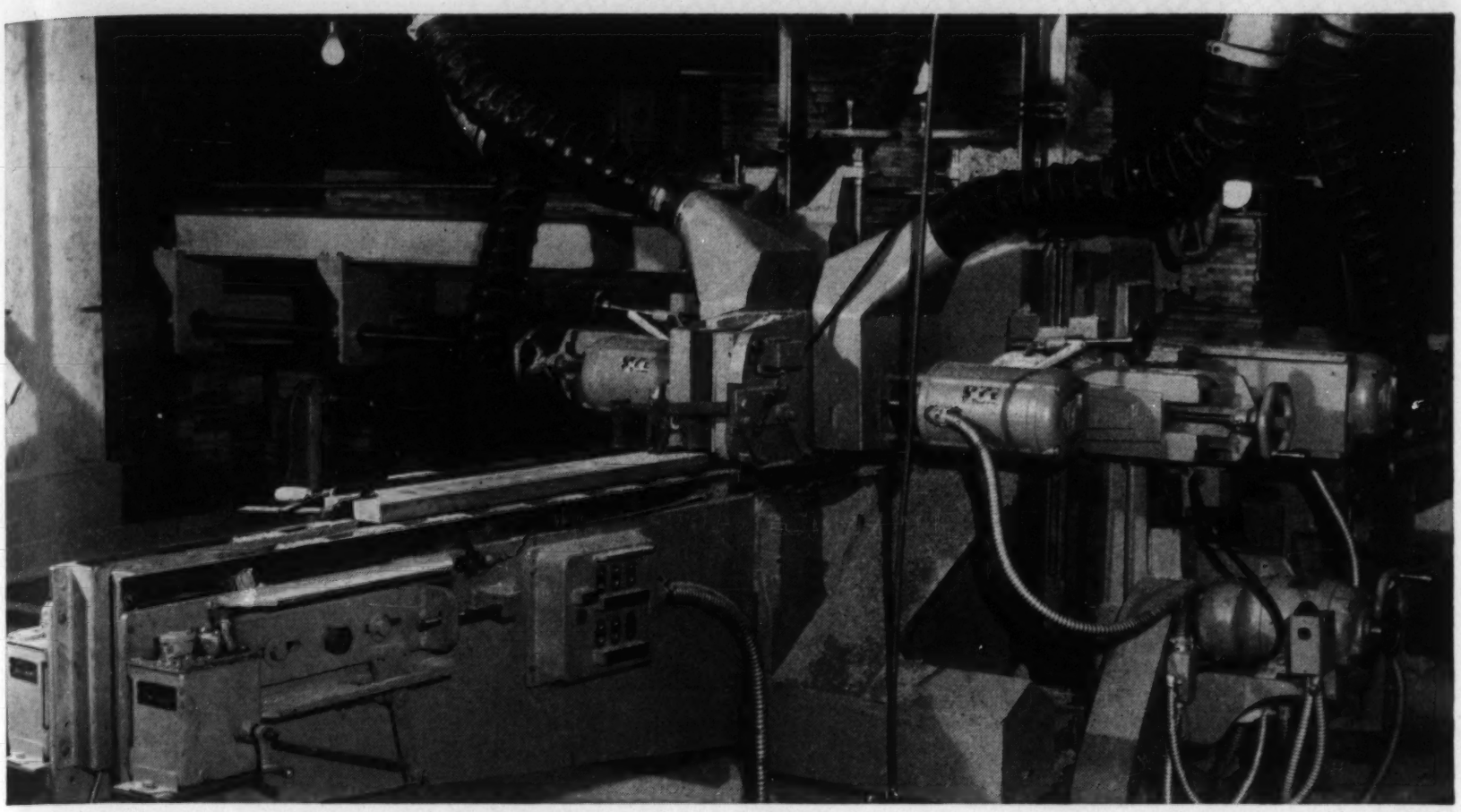
GRAY IRON FOUNDERS' SOCIETY, annual meeting. Cleveland. Oct. 16-17, 1952.

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION, annual meeting. White Sulphur Springs, W. Va. Oct. 16-18, 1952.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div. fall meeting. Philadelphia. Oct. 20-22, 1952.

NATIONAL METAL CONGRESS AND EXPOSITION. Philadelphia. Oct. 20-24, 1952.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Oct. 22-24, 1952.



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Recently a woodworking equipment manufacturer found that an installation of his equipment wasn't living up to expectations. Rigid, slip-jointed ducting for dust removal was breaking off . . . because the machine was in a tight spot . . . and there wasn't enough room for play. One of Flexible's line of new-type tubing, SPIRATUBE®, was installed. That did the trick. Now, this manufacturer is supplying SPIRATUBE with equipment for installation under low ceiling conditions with connecting metal parts built right in!

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No exposed wire to rust or obstruct air passage

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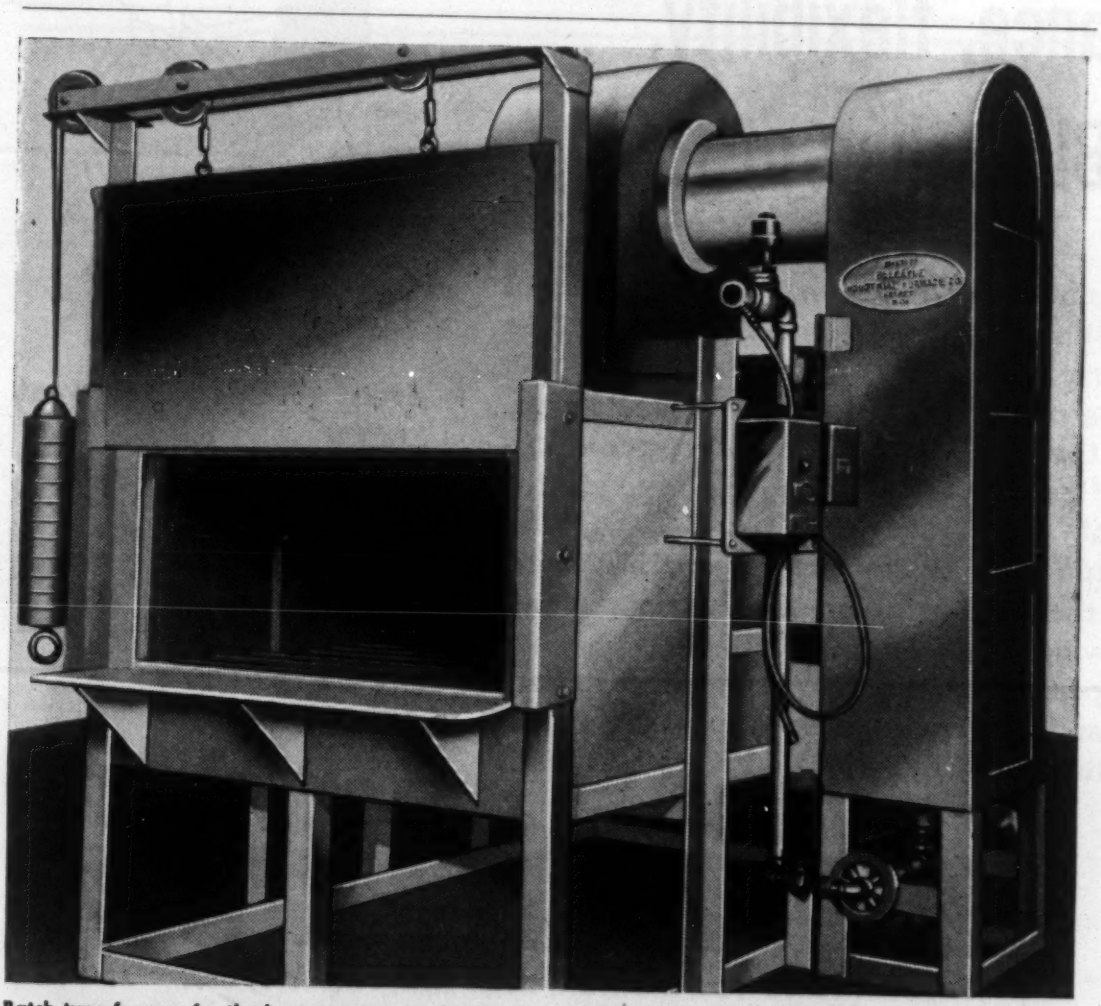

Batch type furnace for the heat treating of aluminum alloys—consists of atmosphere type burner mounted on the lower end of the duct which is used for re-circulating the air back into the furnace. Garden City high temperature fan is standard equipment for recirculating the heated air. This method of heating holds temperature with little or no variation. Mounting the burner in the duct, eliminates the necessity of an extra heating unit. . . . Send us your heat treating problems . . . our engineers will make a proposal without obligation.

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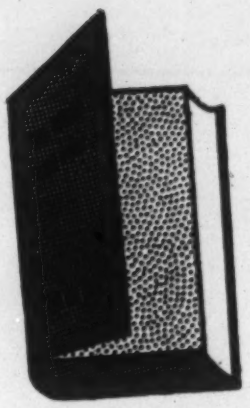


BOOK REVIEWS

Practical Metallurgy

PRACTICAL METALLURGY FOR ENGINEERS. *Published by E. F. Houghton & Co., Philadelphia 33, Pa., 1952. Cloth, 6 by 9 in., 599 pages. Price $3.50.*

To aid metallurgists faced with new production problems in a defense economy, a fifth edition of Practical Metallurgy for Engineers offers the latest standards and practices followed in the metal industry today, and includes a discussion of future possibilities relating to new metals, new alloying elements and new types of heat treatment.

The revision contains 120 more pages than the previous (1943) edition. New chapters include one on flame and induction heating, which discusses the new developments that have expanded the useful range of both these methods. In addition to a new chapter on carburizing, the revision also contains a new chapter on "Other Surface Hardening Methods". "Heat Treatment of Aluminum Alloys" has been expanded to "Heat Treatment of Nonferrous Alloys," in order to include magnesium and copper allows as well as aluminum alloys.

Revisions have been made throughout the book to incorporate the latest methods and data related to all phases of metallurgy, including the newest AISI steel classifications.

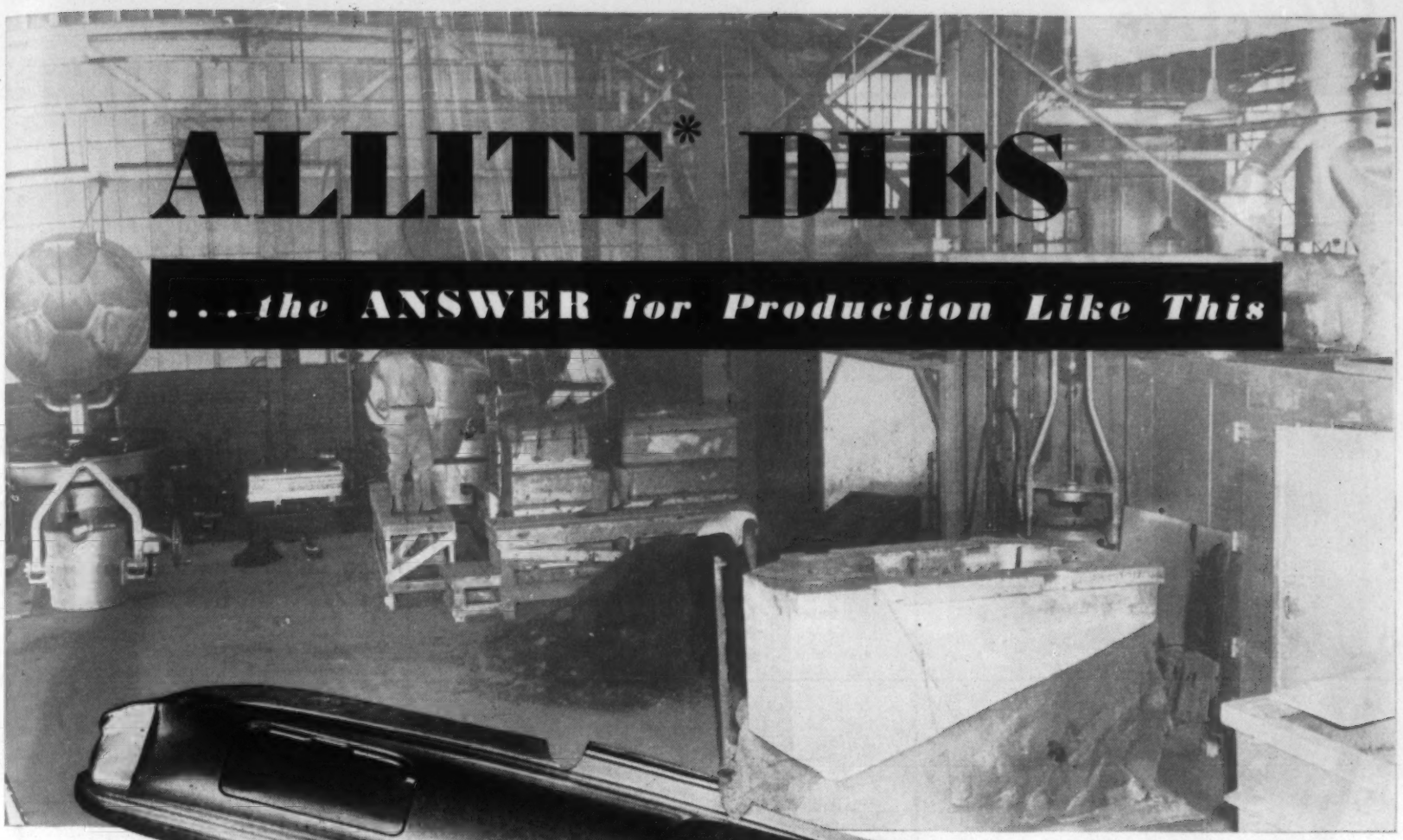
Other New Books

THE WELDING OF NON-FERROUS METALS. *By E. G. West. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1951. Cloth, 5¼ by 8¼ in., 553 pages. Price $8.50.* The purpose of this book is to place on record basic information on the application of the various welding processes to the nonferrous metals, and was written, therefore, with two main classes of reader in view: the welding engineer, welding operator, welding instructor

(Continued on page 210)

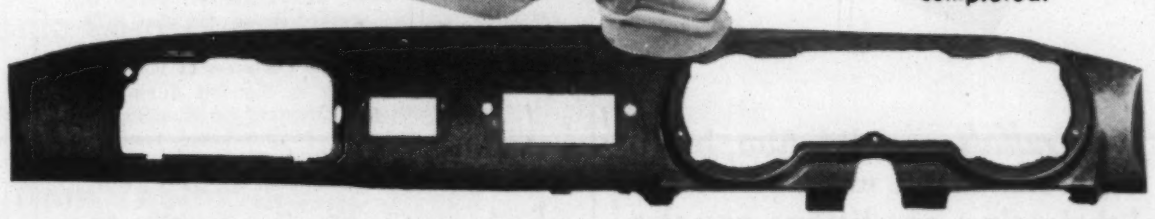
ALLITE* DIES

...the ANSWER for Production Like This



At left is the stamping after the draw.

Shown below is the panel after all operations are completed.



*ALLITE dies are accurately cast for low cost tooling. The material used is any formula of zinc alloy (Kirksite, Di-Metal, etc.) which meets your requirements.

Allite Dies were used as the tooling for this right-hand instrument panel. These were the results:

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- **The customer reports that more than 8000 stampings have been produced, with the original Allite draw die still in serviceable condition. This die is 100% zinc alloy.**

This is typical of many Allite Die applications where all the advantages of low cost tooling, faster production starts and accurately built tools have been combined. And that has only been made possible by the close coordination of foundry and die shop facilities which only Allied can offer.

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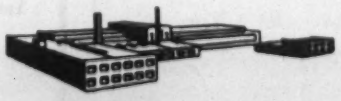
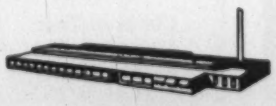
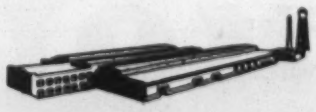


PLANT 2
Detroit, Mich.



PLANT 3
Hillsdale, Mich.



PLANT 4
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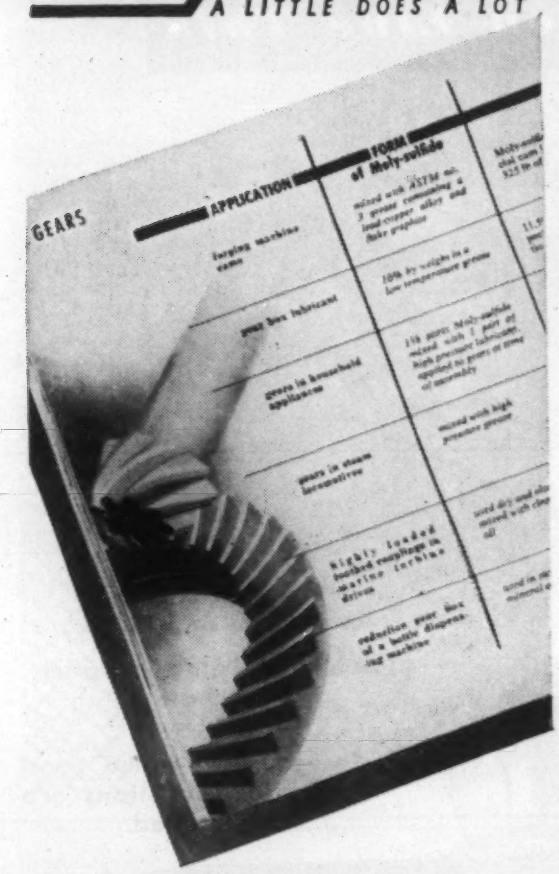
Effective even where other lubricants have failed

Moly-sulfide

A LITTLE DOES A LOT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mixed with high pressure grease

Moly-sulfide, a solid film lubricant, stands out most where the lubricating conditions are the most difficult. If you have to contend with extreme conditions of pressure, temperature, fretting, or velocity, you should try ***Moly-sulfide***. First write for a copy of this free 40-page booklet which shows where the above conditions have already been overcome in the shop and in the field.

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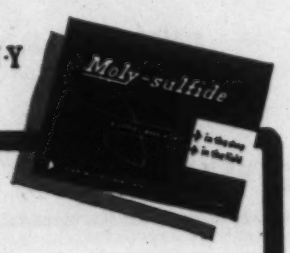

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Book Reviews

(continued)

and trainee on the one hand, and the designer, works engineer and metallurgist on the other.

REPORT ON THE ELEVATED-TEMPERATURE PROPERTIES OF STAINLESS STEELS. *By Ward F. Simmons and Howard C. Cross. Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1952. Paper, 8½ by 11 in., 116 pages. Price $4.00.* Special Technical Publication No. 124 is essentially a graphical summary of elevated-temperature data for the commercially produced stainless steels, issued under the auspices of The Data and Publications Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

FORGING AND FORMING METALS. *By S. E. RUSINOFF. Published by the American Technical Society, Chicago 37, Ill., 1952. Cloth, 5¾ by 8½ in., 279 pages. Price $3.95.* Impact forging, press forging, upset forging, extrusion, heat treatment of forgings, cleaning and finishing forgings, inspection, safety, metal quality and the designing of forgings and tools and dies are all thoroughly covered in this book.

PLASTICS AND BUILDING. *By E. F. Mactaggart and H. H. Chambers. Published by Pitman Publishing Corp., New York 36, N. Y., 1951. Cloth, 7½ by 10 in., 181 pages. Price $12.00.* An account, both wide and detailed, of the chemistry, manufacture and uses of plastics, with emphasis on their application in the building and allied industries.

RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION AND OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL UNITS, *1950. Published by the National Bureau of Standards, Washington, D. C., 1951. Paper, 5⅛ by 7¼ in., 29 pages. Price 15¢.* Handbook 47 gives the recommendations agreed upon by the International Commission on Radiological Protection of the International Congress of Radiology at its recent meeting in London during the Sixth International Congress of Radiology in July 1950, and may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

TITAN—SYSTEM No. *41. Available from Stechert-Hafner, Inc., 31 E. 10th St., New York City. 511 pages. Price $27.20.* This latest volume of the world-famous Gmelin Handbuch presents a complete review of the geology, geochemistry, metallurgy, chemistry, physics and technology of titanium, its alloys and compounds.

THERMODYNAMICS OF ALLOYS. *By John Lumsden. Published by the Institute of Metals, London, England, 1952. Cloth 5¾ by 8¾ in., 384 pages. Price $5.50.* This book deals with thermodynamics as a means of correlating, codifying and cross-checking diverse physicochemical measurements on metals and alloys.

SELECTION, TRAINING AND USE OF PERSONNEL IN INDUSTRIAL RESEARCH. *Edited by David B. Hertz. Published by King's Crown Press, New York 27, N. Y., 1952. Paper, 5½ by 8½ in., 274 pages. Price $4.50.* This volume contains the proceedings of the second annual conference on industrial research, held in June 1951, and sponsored by the Dept. of Industrial Engineering, Columbia University.

CORROSION TESTING. *By Francis L. LaQue. Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1951. Paper, 6¼ by 9¼ in., 89 pages. Price $1.50.* The 1951 ASTM Edgar Marburg Lecture—Corrosion Testing—comprises a survey of corrosion testing programs and methods of corrosion testing, many of which have been sponsored by the ASTM.

CUTTING-TOOL MATERIALS. *By Eric N. Simons. Published by Pitman Publishing Corp., New York 36, N. Y., 1951. Cloth, 5¾ by 8¾ in., 180 pages. Price $4.50.* A comprehensive and authoritative book on the various types of steels and alloys used in cutting tools, describing their applications, heat treatment and composition.

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58 Beryllium Copper
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60 Wire as an Engineering Material
61 Extruded Metal Shapes & Their Uses
62 Ceramics for Engineering Applications
63 Heat Resistant Castings
64 Mechanical Finishing of Metals—for Decorative Purposes
65 Welding Electrodes and Rods—for Ferrous & Nonferrous Metals
67 Nondestructive Testing of Engineering Materials and Parts
68 Glass as an Engineering Material
69 Cleaning and Finishing Stainless Steels
70 Compression Molded Plastic Parts
71 Wrought Aluminum Alloys
72 How to Overcome Materials Shortages in Product Design and Manufacture
73 Die Castings
74 Wrought Phosphor Bronzes
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